The governance of risk in European livestock systems

MSc Thesis
Rural Sociology
Resilient Food and Farming Systems

Wageningen University & Research

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Positionality Statement

As social identity and research practice cannot be separated from one another, positionality is key in articulating potential biases and assumptions that influence this research. I am an upper-class European citizen and am fluent in two languages, English and Dutch. This citizenship is contrasted by an international upbringing in countries such as the US, Russia, the UK, and Italy. While living in these countries, I was educated according to British, American, and Dutch curricula. Currently, I attend Wageningen University & Research for an advanced degree in agriculture and have represented the institution at a SCAR event. I was the youngest female attendee of the event.

Due to a chronic illness, I do not consume an average diet. In line with this, I was vegan for years and currently eat very limited amounts of meat. As a member of generation Z, I note the popularity of plant-based diets and tailored diets in the US and Europe. The discourse of my lifetime and class has not been around food security or safety, but rather in consumer choice, nutrition and the environment.

Introduction

Against a backdrop of socioeconomic tension, climate change and resource scarcity, the need for sustainability is evident[1]. The term 'sustainability' has become a contemporary megatrend of which the definition(s) have the potential to cause more confusion than focus. Sustainability is a label that depends on normative premises, meaning it cannot be objectively defined and is not fixed in its objectives and outcomes. Having said this, a key thread in articulations of sustainability in academic literature is the ability of a system to provide for current and future needs, depending on the context these may be more financially, socially, environmentally or oriented otherwise. According to Vos[2] core elements of sustainability consist of three key components; "equity, ecology, and economy". This is a summation of the popular notion of the three pillars of sustainability: economy, environment, and social elements[3]. So, while there may be varying sectoral emphases in general when sustainability is mentioned there is reference to these pillars, individually or collectively.

A sector that has incurred particular controversy related to all areas of concern is agriculture. By the metric of the planetary boundaries, as conceptualised by Rockström et al.[4], agriculture, both arable and livestock have a critical impact on the environment[5]. While crop farming and animal agriculture are intrinsically linked, this research will focus on the latter. Animal agriculture entails the full value chain of breeding, rearing, processing and consuming domesticated animals such as cows, sheep, chicken and pigs. Contemporary livestock production in particular strains the global environment. Its production cycles damage terrestrial habitats, encouraging deforestation for the creation of grazing lands for cattle. Further impacts include the significant contribution to greenhouse gas emissions such as nitrogen and methane associated with large ruminants[6]. According to the FAO, in 2015 livestock contributed approximately 11% of total anthropogenic emissions[7]. Evidently the sector is a key contributor to the changing climate, simultaneously making it a prime potential for emissions mitigation strategies.

Animal source foods are key components of contemporary diets, in the current modern European economy the industry employs millions, provides incomes, and feeds not only inhabitants of the EU but all countries that can be reached by globalised supply chains[8]. Meeting these demands has been in part fulfilled by intensification of livestock production systems, which in turn increases the risk of disease outbreaks[9] and magnifies the concerns over animal health and welfare. Predictions forecast that animal

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1 Shukla et al., "IPCC, 2019: Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems."

2 Vos, Robert O. "Defining sustainability: a conceptual orientation." *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology* 82, no. 4 (2007): 334-339.

3 Peyraud, Jean Louis, INRAE, Saggau, Elke, BLE, and Bassler, Arnd, BLE. "COMMON STRATEGIC RESEARCH AND INNOVATION AGENDA." *Https://Www.Era-Susan.Eu/Content/Susan%E2%80%99s-Common-Strategic-Research-and-Innovation-Agenda*. Cofund ERA-NET "Sustainable Animal Production Systems" (SusAn), February 2022.

4 Rockström, Johan, Will Steffen, Kevin Noone, Åsa Persson, F. Stuart Chapin, Eric F. Lambin, Timothy M. Lenton et al. "A safe operating space for humanity." *nature* 461, no. 7263 (2009): 472-475.

5 Campbell, Bruce M., Douglas J. Beare, Elena M. Bennett, Jason M. Hall-Spencer, John SI Ingram, Fernando Jaramillo, Rodomiro Ortiz, Navin Ramankutty, Jeffrey A. Sayer, and Drew Shindell. "Agriculture production as a major driver of the Earth system exceeding planetary boundaries." *Ecology and society* 22, no. 4 (2017).

6 Gerber, Pierre J., Henning Steinfeld, Benjamin Henderson, Anne Mottet, Carolyn Opio, Jeroen Dijkman, Allessandra Falcucci, and Giuseppe Tempio. *Tackling climate change through livestock: a global assessment of emissions and mitigation opportunities*. Food and Agriculture Organization of the United Nations (FAO), 2013.

7 Model, ENVIRONMENTAL ASSESSMENT. "The global livestock environmental assessment model." *Food and Agriculture Organization of the United Nations (FAO)* (2017): 22-6.

8 OECD, F. A. O. "OECD-FAO Agricultural Outlook 2022-2031." (2022).

9 Jones, Bryony A., Delia Grace, Richard Kock, Silvia Alonso, Jonathan Rushton, Mohammed Y. Said, Declan McKeever et al. "Zoonosis emergence linked to agricultural intensification and environmental change." *Proceedings of the national academy of sciences* 110, no. 21 (2013): 8399-8404.

source foods will remain a part of diets for the foreseeable future, with consumption increasing especially in developing countries[10], thus the future of food will in part be shaped by animals and their footprint(s).

Animal agriculture plays a key role in European economies, from member state to union level. According to Vinci[11], "In 2020, there were over 76 million cattle in the European Union (EU) and beef production reached 6.8 million tonnes – output that makes the EU the world's third largest producer, after the United States and Brazil". Furthermore, in 2016 there were over 9 million farms in the EU, of which over 300,000 were specialised in cattle[12][13]. The industry plays a key role in many European incomes, with 58% of farms holding animals. In addition, the estimated value of the livestock sector in the EU reached € 170 billion, making up 40% of all agricultural activity in the Union[14]. It is clear that the livestock sector plays a prominent role in European livelihoods, not only among farmers and rural development, but also for food processors, distributors and consumers. Especially as Europeans on average consume more than twice the global average of animal protein[15]. Paired with these considerations is the strained political context of livestock farming in Europe. As a product of the misalignment of Vos[16]' 'equity, ecology, and economy' signs of tension and risk are mounting.

Misalignment of these pillars results in risks in the food sector and beyond. In its simplest form, risk is the likelihood that negative consequences will be incurred as a result of an action or condition[17]. Environmental risk then takes into account the bio- and ecological variables that may be impacted as a consequence of actions or conditions. Commonly recognised environmental risks include exceeding 1.5 degrees of warming, air quality reduction by pollution or increased severity and frequency of extreme weather events[18][19]. All human systems depend in one way or another on the stability of the global environment and so a disruption of these systems will have widespread impacts across demographics, geographies and sectors. The management of such risks is dependent on the extent to which the consequences can be quantified, the certainty of severity, as well as the potential solutions and the mobilisation of stakeholders. The recognition of threats such as climate change, soil degradation and unstable incomes contribute to risk. First and foremost the risk that the livestock industry will not survive, as in it will be unable to supply sufficient nutrients, incomes and ecosystem services. Secondly, but arguably equally or more importantly, the inability of the livestock sector to function sustainably threatens the food system as a whole, and in turn global systems dependent on food.

In Europe, the precautionary principle is a way in which the union approaches risk management. This principle follows a 'better safe than sorry' approach towards uncertainty. Where risk is established, the

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10 OECD, F. A. O. "OECD-FAO Agricultural Outlook 2022-2031." (2022).

11 CLAUDIA, VINCI. "European Union beef sector: Main features, challenges and prospects." (2022).

12 CLAUDIA, VINCI. "European Union beef sector: Main features, challenges and prospects." (2022).

13 Eurostat. "Farms and Farmland in the European Union-Statistics." (2019).

14 Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

15 Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

16 Vos, Robert O. "Defining sustainability: a conceptual orientation." *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology* 82, no. 4 (2007): 334-339.

17 Muralikrishna, Iyyanki V., and Valli Manickam. "Environmental risk assessment." *Environmental management* (2017): 135-152.

18 White, Owen, Kenisha Garnett, Tony Zamparutti, Rolands Sadauskis, and Spela Kolaric. "The EU Environmental Foresight System (FORENV) – Final Report of 2020-21 Annual Cycle Emerging Issues Impacting the Delivery of a Zero-Pollution Ambition by 2050 : Emerging Issues Impacting the Delivery of a Zero-Pollution Ambition by 2050." *Https://Op.Europa.Eu/En/Publication-Detail/-/Publication/0c49a67d-9523-11ec-B4e4-01aa75ed71a1/Language-En/Format-PDF/Source-251852332*. Publications Office of the European Union, 2022. https://data.europa.eu/doi/10.2779/653635.

19 Mukherji et al., "SYNTHESIS REPORT OF THE IPCC SIXTH ASSESSMENT REPORT (AR6)."

union claims to favour action rather than inaction even when the full extent of the threat cannot be assessed. The principle has already been applied to the EU general regulation on food law as well as to the regulatory framework on chemicals[20], among others. As it pertains to the livestock sector, it seems that the precautionary principle is limited in its application. In this context, the principle has been implemented to manage risk for feed additives therein engaging with disease prevention, growth hormone regulation, and antibiotic resistance[21]. Generally speaking, throughout the literature and documentation of the precautionary principle in the EU, food safety is targeted rather than environmental risks such as emissions or groundwater contamination by waste[22]. While in its original conception in the Maastricht Treaty, the principle explicitly includes environmental protection elements, in practice it seems to be mostly focused on human health via food safety[23]. This relatively short-term application of risk management neglects the long term risks associated with the livestock sector, such as its contribution to GHG emissions or ecosystem functioning.

Having established that sustainability can be difficult to define consistently, alongside the current pressure on livestock production systems results in a need to gauge how we define sustainability for livestock. A cohesive and consistent definition of sustainability for livestock will then guide governance, which is a critical component of achieving sustainability. Governance as a key solution for managing problems related to the environment has long been recognised. Some credit the UN FAO's Livestock's Long Shadow to being the first widely published and scientific piece to link animal agriculture to environmental degradation, and in doing so implicating policy and governance. This landmark report places the livestock sector at a top 3 position in its contribution to the most pressing environmental challenges such as biodiversity loss, atmospheric gas concentrations, water and land degradation[24]. Even at the time of publishing, in 2006, the importance of policy and governance were identified as fundamental to mitigating some of the negative impacts of agriculture. Yet in 2022, at the European Union level no such thing as a 'sustainable livestock policy' exists. While the EU has expressed a range of ambitions targeted at agriculture and livestock such as in the European Green Deal and the Farm to Fork strategy, there is no overarching policy document or framework, such as the Common Agricultural Policy, to guide member states to a sustainable future of livestock[25].

In order to achieve a sustainable livestock sector, cohesive and collaborative efforts across governments, sectors and stakeholders will need to be realised. While the problem is composed of myriad dimensions, the focus here will be on the interplay between science and policy as well as the capacity for policy to drive sustainability for livestock in the EU. Strong policy design and implementation depends on the identification of the problem, assessment of tradeoffs and alignment with other policies or regulations. The latter is especially pertinent to this research. As the European Union is composed of Members who operate both in their own context alongside the Union context, alignment among national and international strategies is essential. Alignment in the assessment of the severity of the issue, thus the priority assigned to it, stakeholders included and selected solutions all contribute to the outcome of the policy. While the European Commission (EC) is and has been investing in sustainability and

[20] European Commission. "Precautionary Principle." EUR-Lex. Accessed June 28, 2023. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=LEGISSUM:precautionary_principle.

[21] Bourguignon, Didier. "The precautionary principle: Definitions, applications and governance." (2015).

[22] Van Herten, J., and B. Bovenkerk. "The precautionary principle in zoonotic disease control." *Public health ethics* 14.2 (2021): 180-190.

[23] De Smedt, Kristel, and Ellen Vos. "The application of the precautionary principle in the EU." *The Responsibility of Science* 2 (2012): 163.

[24] Steinfeld, Henning, Pierre Gerber, Tom D. Wassenaar, Vincent Castel, Mauricio Rosales, Mauricio Rosales, and Cees de Haan. *Livestock's long shadow: environmental issues and options*. Food & Agriculture Org., 2006.

[25] European Commission. "Farm to Fork Strategy." European Union, 2020. https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf.

development in agriculture in the Union for decades, at present the policy landscape for livestock is fragmented. This fragmentation exists in comparing union level to member state policies, union policies as a whole, as well as among member states. This misalignment is evident in multiple layers of European governance, signalling a potential barrier to mitigating risks in livestock.

The European Common Agricultural Policy (CAP) initially served the purpose of post war recovery in food security and income, but has now expanded to encompass environmental and broader social benefits such as rural development. It governs European agricultural value chains, in particular at the farm level. Its lifetime spans from 1962 to today (2023), focusing mostly on farmer incomes through subsidies and other financial support. The CAP consists of two pillars, under which a number of mechanisms are stacked to incentivize farming practices and support rural development[26]. Some of the mechanisms in place to support environmentally friendly practices (as defined by the EC) include eco-schemes and enhanced conditionality. These promote practices such as organic farming, extensive grazing, and the planting of hedgerows[27]. In terms of livestock farming, the CAP has very few targeted approaches to improve the industry. Of the 48 progress indicators, there are 4 metrics directly related to livestock: livestock units, farming intensity (consisting of 2 sub indicators: farm input intensity and areas of extensive grazing), emissions from agriculture, and sales/use of antimicrobials in food producing animals[28]. Most recently, the CAP process required Member States to submit national strategic plans to adhere to regulations and reach objectives set out by the policy. While the strategic plans exhibit alignment as they are in direct response to EU conditions, on a livestock level the interventions are limited. The majority of incentives and instruments are aimed at arable farming as opposed to livestock-specific solutions. The explicit gap here is (1) the overall lack of targeted livestock strategies to reduce risk in the sector, (2) the lack of policy instruments aligning with these strategies and (3) alignment across European Union and Member State policies for livestock.

Ultimately, in order to secure a sustainable future for the industry and all the people depending on it for nourishment, livelihoods and cultural heritage, better management of risk and improved alignment across levels of governance in European policy for livestock is needed. Adopting risk assessment and management practices can mitigate the risks before damages are done. Assessing risks for the livestock sector through concerted scientific efforts followed by appropriate governance responses may prevent the surpassing of tipping points. This thesis is an exploration of this process, starting with the assessment of risk in European livestock production. This risk is paralleled with policy on both the EU and Member State levels. Ultimately the alignment between risk and policy will be established to determine how the European Union is governing for risk in the livestock sector.

The next section of this thesis will introduce the research questions that guide the policy exploration that follows. The research questions outline the main lines of inquiry, after which a literature review will present the status quo of policy and risks facing the European livestock sector. The methods section shows how the literature review was conducted and structured. Thereafter, an analytical framework will be contextualised for the purpose of this thesis; that is the assessment of risk and alignment in European policies. The analytical framework is then followed by the findings of the assessment of alignment.

[26] Candel, Jeroen. "The Saga of European Agriculture Policy." Slide show, Wageningen University & Research, 2021.

[27] European Commission. "Factsheet practices under ecoschemes." 2021. https://agriculture.ec.europa.eu/system/files/2021-01/factsheet-agri-practices-under-ecoscheme_en_0.pdf

[28] European Commission. "CMEF 2014-2020 Context Indicators." 2023. https://agriculture.ec.europa.eu/system/files/2023-01/context-indicator-fiches_en.pdf

In order to provide structure to this thesis, six categories will guide the discourse. These were established in collaboration with the secretary of the Standing Commission on Agricultural Research Collaborative Working Group on Sustainable Animal Production (SCAR CWG SAP). SCAR SAP is an EU funded science-policy interface that provides scientific input to the Commission to inform policy[29]. In October of 2022 the working group came together for a workshop in Bonn, Germany to discuss a future of sustainable livestock in the EU. This workshop derived its mission from ERA NET SusAn (Sustainable Animal Production Systems), which identified the need for a vision of European sustainable livestock production[30]. The Bonn workshops were structured using the following eight headline topics:

(1) greenhouse gas emissions
(2) diversity
(3) economy
(4) consumption
(5) animal health and welfare
(6) organic agriculture
(7) circularity and
(8) resilience.

These guided the discussion and in an overarching way covered the broad pathways and in turn specific interventions that could make up a 'sustainable future of livestock'. Each headline category was also accompanied by a keynote presentation in which the latest academic literature and findings were used to characterise the importance of each category for the sustainable future of livestock. While there is no set definition for a sustainable livestock sector, using these categories can help streamline an understanding of the risks facing livestock sustainability.

This research accounts for the first six of these topics, leaving out circularity and resilience. The omission of these two is due to the focus of this thesis, which is risk governance through policy alignment. Circularity and resilience can be considered solutions or mitigation of risk, while the remaining six categories are each associated with clear risks, each of which will be established as part of this review.

Research Question(s)

The current policies governing livestock production in the European Union, the research gap here is the alignment of risk governance across the sector. The existing literature on risk is limited in its application to EU livestock systems, often extending to global food or agricultural systems. Risk governance is often singled out as a broad strategy that is not applied to a sector in particular. With the literature review it has been established that there is no coherent policy or policy instrument representing a framework for sustainable livestock production in the EU.

In order to find out what elements are currently being addressed in policies alignment between EU, member state and risk literature will be conducted. In turn, the alignment or lack thereof could serve to

[29] SCAR. "Mission and Aims," 2022. https://scar-europe.org/spa-mission-and-aims.

[30] Peyraud, Jean Louis, INRAE, Saggau, Elke, BLE, and Bassler, Arnd, BLE. "COMMON STRATEGIC RESEARCH AND INNOVATION AGENDA." *Https://Www.Era-Susan.Eu/Content/Susan%E2%80%99s-Common-Strategic-Research-and-Innovation-Agenda*. Cofund ERA-NET "Sustainable Animal Production Systems" (SusAn), February 2022.

inform a future framework for livestock risk governance. Areas in which there is already agreement among risk, EU and member state policies may be easier to implement than politically fraught or conflicting approaches.

Therefore, this research aims to answer the following questions:

Main Research Question:

To what extent is there alignment between Member State and EU policies on the risks associated with the future of the livestock sector?

Sub Questions:

- Are policies (EU, Member States level) adequately aligned with risks?
    - When comparing across sources, what are the gaps and commonalities?
- How is sustainable livestock characterised in the current policy landscape?

Methods

Four main data sources inform the analysis in this thesis: Scientific literature is used to assess the risks. Then EU policy, risks threatening the livestock sector, and Member State livestock/environmental strategies form the data that is analysed to answer the research questions (see Appendix 1 for an overview of the latter). The analysis of the governance of risk in EU livestock systems will be derived from a comparison between these three. EU policy documents, that is those published and authorised by the European Commission or Parliament, were collected via an independent search. At times these documents are legally binding and enforced, such as the Animal Breeding Regulation. Also included were broader strategies such as the Organic Action Plan, and the EU Animal Welfare Platform. To be included in the review, there needed to be explicit links to livestock as well as some form of targets, actions and goals at a European level. Oftentimes, a quick search was used in order to establish the relevance to the livestock sector. Here, search terms such as 'livestock', 'animal', 'antibiotics' or 'cattle' were used.

Sectoral risks were identified by way of a literature review, the details of said risks fall in line with the overarching structure of the SCAR risk categories. Familiar sources from my undergraduate and graduate degrees served as an addition to the knowledge base that informed the selection of overarching risks. Sources such as the IPCC, EEA, FAO among others were considered scientifically rigorous and appropriate for this thesis.

EU Member State documents were provided by contact points at Member State ministries. These documents ranged from broad environmental policies to targeted livestock antibiotic resistance strategies. Each ministerial contact was informed of the nature of the research. Some documents were supplied in non-English languages, therefore DeepL was used to translate to English. Here the limitations of translation are recognised, some scientific, political or cultural nuance may have been lost. Where there were no documents delivered an independent search was conducted. Appendix 2 lists all the Member State documents used in this analysis. 19 Member States (including the UK) were

analysed. Additional information on Member State policies relating to livestock was occasionally supplied by broader EU policies or studies done by the EEA, OECD, IPES or ERPS[31][32][33][34].

The coding of these documents was done using Atlas.ti. A deductive, qualitative coding method was applied. Codes followed the original eight SCAR categories: (1) Animal health and welfare, (2) Circularity, (3) Climate change and greenhouse gas mitigation, (4) Consumption, (5) Economy, (6) Diversity (including biodiversity), (7) Organic agriculture, (8) Resilience. Some additional categories such as International Agreements, Targets and Ambitions aimed to further inform priorities and objectives among Member States. The definitions of each category, excluding resilience and circularity for reasons described previously, can be found in the table below.

Code	Definition
Animal health and welfare	Direct reference to how the national government addresses the theme in terms of policy/targets/solutions. Mention of: veterinary medicines, feed composition, housing and transport conditions Indicators, definitions, metrics
Climate change and greenhouse gas mitigation	Direct reference to how the national government addresses the theme in terms of policy/targets/solutions. CO2 or equivalent mentioned. Reduction and mitigation strategies Indicators, definitions, metrics
Consumption	Direct reference to how the national government addresses the theme in terms of policy/targets/solutions. Included healthy diets, dietary recommendations, food safety, labelling and transparency oriented at consumers
Economy	Direct reference to how the national government addresses the theme in terms of policy/targets/solutions. Included labour, costs of transitioning, investments, funds dedicated to climate mitigation/adaptation
Diversity (including biodiversity)	Direct reference to how the national government addresses the theme in terms of policy/targets/solutions. Indicators, definitions, metrics
Organic agriculture	Direct reference to how the national government addresses the theme in terms of policy/targets/solutions. Indicators, definitions, metrics

[31] European Environmental Agency. “Transforming Europe’s Food System - Assessing the EU Policy Mix.” Publications Office of the European Union, 2022. https://doi.org/10.2800/295264.

[32] De Schutter, Olivier. “Towards a Common Food Policy for the European Union.” IPES-Food panel, 2019. http://www.ipes-food.org/pages/CommonFoodPolicy.

[33] OECD, F. A. O. "OECD-FAO Agricultural Outlook 2022-2031." (2022).

[34] CLAUDIA, VINCI. "European Union beef sector: Main features, challenges and prospects." (2022).

The previously outlined questions guiding my data analysis will form a basis for how the EU is governing risks in livestock production. The metrics, boundaries, knowledge characterisation and solutions/recommendations will be compared and assessed by the extent to which they correspond across the data (EU policy, Member State policy and risks). Alignment will be assessed among European policies, that is the extent to which policies recognise risks, define them, characterise uncertainty and complexity, as well as the solutions that are offered. This approach mimics the OECD assessment of a low-carbon economy outlined in the previous section. Essentially, alignment will reflect on the EU and Member State orientation to risk, reflected by their priorities and objectives. There will be five assessments of alignment for each of the six SCAR categories:

(1) across EU level policies
(2) among Member State strategies
(3) between EU and Member States
(4) EU and risks, and
(5) Member States and risks.

Alignment will be labelled either as misaligned, or aligned. Alignment will be determined in part through consistency. That is, if one of the six categories is characterised consistently across EU and Member State policies. If methane reduction is recognised as key in order to mitigate emissions in both EU and Member state policies, it will be considered aligned. This will be repeated across metrics, knowledge characterisation, boundaries and recommendations/solutions. If the majority of components identified in the metrics category are consistent across data being compared, it will be considered 'aligned'. Granted, this is a subjective assessment and many more indicators could be used to assess alignment but for this qualitative, varied data this is most convenient to give a broad overview of elements of risk governance.

(Future) risks to the EU livestock sector: A Literature Review

The following section summarises the current state of European policies related to livestock production, with a focus on sectoral risks. The policies consist predominantly of legislation implemented by the European Commission, Parliament and related institutional bodies that are responsible for governing the union. The aim of this review is to set a baseline for the status quo of livestock governance at the union level. The assumption here is that the Commission sets certain legal and other standards for Member States to adhere to. Thus, the frameworks set at a Union level may give an indication as to how Member States govern national production systems. This section consists of an introduction each of the six topics, followed by their European context, overarching risks facing the Union and beyond and finally, current relevant EU level policy. The aim of this review is to establish where the livestock sector currently stands in terms of governance and risk.

Through the lens of the six categories introduced above, the CAP addresses sustainable livestock in a limited way. Out of the six categories, it addresses four; animal health and welfare, emissions, organic agriculture and economy. While the majority of the categories are addressed, the extent to which the measures incentivized by the CAP promote sustainability, that is a balance of Vos[35], 'equity, ecology,

[35] Vos, Robert O. "Defining sustainability: a conceptual orientation." *Journal of Chemical Technology & Biotechnology: International Research in Process, Environmental & Clean Technology* 82, no. 4 (2007): 334-339.

economy', remains unclear. The European Green Deal includes a more comprehensive approach to agriculture than previously expressed in EU policy.

The Green Deal is the overarching EU policy package for managing climate change. It is composed of a number of policies and strategies each targeting different sectors. Examples that are directly relevant to the food sector are the Organic Action Plan, the Farm to Fork and Biodiversity Strategies. The Farm to Fork and Biodiversity strategies set out clear targets for standards in animal health and welfare, as well as for emissions and other pollutants from agriculture. Both describe the need for transitions in the food system to build resilience and the importance of the role of the environment in the future of food[36]. These transitions are described as requiring shifts throughout the value chain and beyond, therefore adopting a food *systems* approach. Similarly, both consider the way forward for European food systems to be a balance between social, economic and environmental elements. Specifically, the components that make up this balance include a reduction in synthetic pesticide, fertiliser and antimicrobial use, organic farming, animal welfare and biodiversity. Under the broad umbrella of these categories are targeted approaches such as the promotion of genetic diversity in plants and livestock, conservation and preservation of grasslands and high value natural habitats. There is also a clear priority set, which is food security and safety for consumers in the Union. This priority underlines the policies, as stated in the Farm to Fork Strategy; "Food security and food safety are cornerstones of our food system, and will never be compromised.[37]". At the time of writing, the EU is developing an initiative called the 'Sustainable EU food system' which aims "...to integrate sustainability into all food-related policies"[38]. It is unclear what exactly is meant by 'sustainable', but food labelling, public procurement and governance are included in its scope.

While these pieces of policy promote a generally well-rounded conception of sustainability, the explicit mention and link to livestock is largely absent. Many of the suggested approaches to improve environmental sustainability such as nutrient management could include livestock, especially as livestock in the EU is responsible for 52% of the Union's methane emissions, and 74% of the Union's nitrogen emissions[39]. Other areas that could be explicitly linked to livestock practices include forest and grassland management, genetic diversity, and land use change. Another element that confirms the underrepresentation of livestock in these landmark policies is that the Biodiversity Strategy has a section dedicated to fisheries and aquaculture, but no such section exists for livestock. While the EU has established goals such as a 50% reduction in chemical pesticides, or a 50% reduction in antimicrobial sales both to be reached by 2030[40], a clear, decisive framework for the livestock sector as a whole does not exist. In part, this is due to the diversity in geographic, economic and sectoral specialisation of respective member states[41]. In addition, there is a widespread lack of clear and decisive definitions of sustainability for the food system as a whole, which inevitably transfers to the livestock sector as a component of the food system. Finally, neither the Farm to Fork or Biodiversity Strategy is legally

[36] European Commission. "Biodiversity Strategy." European Union, 2020. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

[37] European Union. "The Farm to Fork Strategy," Slide show 2022. https://food.ec.europa.eu/system/files/2022-04/f2f_international_lac_wkshp_20220322_pres-01.pdf.

[38] European Union. "Sustainable EU Food System –New Initiative," 2021. Accessed May 10, 2023. https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/13174-Sustainable-EU-food-system-new-initiative_en.

[39] Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

[40] European Commission. "Farm to Fork Strategy." European Union, 2020. https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf.

[41] Peyraud, Jean Louis, INRAE, Saggau, Elke, BLE, and Bassler, Arnd, BLE. "COMMON STRATEGIC RESEARCH AND INNOVATION AGENDA." *Https://Www.Era-Susan.Eu/Content/Susan%E2%80%99s-Common-Strategic-Research-and-Innovation-Agenda*. Cofund ERA-NET "Sustainable Animal Production Systems" (SusAn), February 2022.

binding, meaning their success depends on alignment with the CAP or further voluntary policy changes on the member state level.

The next section will present the status quo of risk according to the six SCAR categories. This risk will be linked to the current EU policy landscape. This review will provide an overview of data that will be used in the analysis section of this thesis. Here, an initial look into the relationship between risk and EU policies will give insight into how livestock is expressed in policy, as well as to what extent this is in line with risk literature.

1. Greenhouse Gas Emissions

Through a range of activities such as fertiliser application, land use change, and enteric fermentation agriculture is one of the main contributors to anthropogenic emissions. While at a global scale, emissions attributed to agriculture make up approximately 20% of the total, in the EU-27 this proportion was 10%. Granted, activities generating emissions outside of the EU such as feed production skew this figure. According to Peyraud and Macleod, (2020), about half of the emissions from agriculture in the EU come from livestock[42]. When accounting for processing, transport and processing of animal feed, livestock production is responsible for over 80% of emissions from agriculture in the EU. While fossil fuel combustion is the biggest source of carbon emissions, for agricultural production gases including nitrogen and methane are more pertinent. In the scope of this paper, livestock production is focused strictly on the animal production portion of the supply chain. This means that the carbon emissions that would be associated with processing, machinery or land use change are not accounted for.

The EU's 2030 Climate Target Plan proposes to cut GHG emissions by 55% by 2030 according to the 1990 baseline[43]. In addition, the union has set out to become the first climate neutral continent by 2050. These ambitions are in line with the overarching risk of surpassing tipping points by exceeding 1.5°C of warming. The Intergovernmental Panel on Climate Change (IPCC) has published a series of reports framing the current state of the environment, and the emissions trajectory the Anthropocene currently follows. The most recent report asserts that human activities have unequivocally caused global warming, with temperatures now reaching 1.1°C above 1850-1900 levels[44]. The Panel states with high confidence that continuing current rates of emissions will lead to over 1.5°C of warming. Since the risk for emissions is quantified in gigatonnes of a gas or the percentage contribution of a sector to total emissions, it is clear that livestock is a significant contributor to exceeding 1.5°C of warming. This may trigger feedback loops in water cycles causing drought, heat waves and species losses[45]. Given the interconnected nature of global value chains, changes in weather conditions will impact food supply across the globe. In addition, climate change has the potential to disrupt myriad other systems, compounding the risk exponentially.

In terms of knowledge characterisation, establishing the certainty of the consequences of climate change is a disputed topic. The IPCC includes measures of certainty in its reports, ranging from low to high

[42] Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

[43] EUR-Lex. "Stepping up Europe's 2030 Climate Ambition," 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52020DC0562.

[44] Mukherji et al., "SYNTHESIS REPORT OF THE IPCC SIXTH ASSESSMENT REPORT (AR6)."

[45] Intergovernmental Panel on Climate Change. *Global warming of 1.5° C: An IPCC special report on the impacts of global warming of 1.5° C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Intergovernmental Panel on Climate Change, 2018.

confidence. Figure 1 shows some of the potential impacts of climate change on water availability and food production. The figure demonstrates medium confidence in attributing these risks to climate change for physical water availability and agriculture/crop production[46]. Low confidence is attributed to animal and livestock health and productivity. Figure 2 summarises some of the expected direct impacts on livestock production such as a decline in milk/meat production or increased mortality of animals. Compounding the uncertainty of livestock's role in climate change is the IPCC's statement on uncertainty in emissions: "Agriculture contributes about 47% and 58% of total anthropogenic emissions of CH4 and N2O, respectively, with a wide range of uncertainty in the estimates of both the agricultural contribution and the anthropogenic total[47]". According to myriad sources both the causes and outcomes of risk, while threatening, are uncertain and therefore increase the complexity of the management of risk.

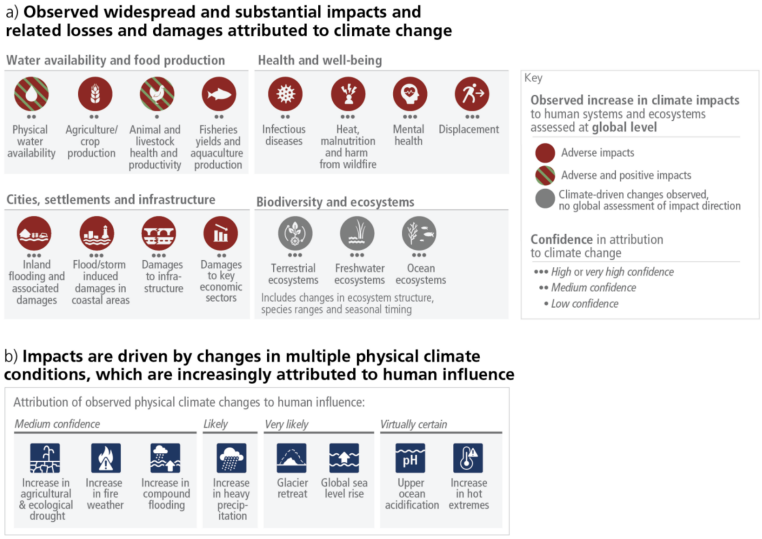

Figure 1: IPCC visualisation of the potential impacts of climate change on various systems.[48]

[46] Mbow, Hans-Otto Pörtner, Andy Reisinger, Josep Canadell, and Phillip O'Brien. "Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems (SR2)." *Ginevra, IPCC* 650 (2017).

[47] Netz, Bert, Ogunlade R. Davidson, Peter R. Bosch, Rutu Dave, and Leo A. Meyer. "Climate change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policymakers." *Climate change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policymakers.* (2007).

[48] Mbow, Hans-Otto Pörtner, Andy Reisinger, Josep Canadell, and Phillip O'Brien. "Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems (SR2)." *Ginevra, IPCC* 650 (2017).

Impact Type	Observed Impacts	Major Influential Factors
Direct Impact	Reduced feed intake	Increased temperature (heat stress)
	Decline in animal milk and meat production	
	Decreased reproductive performance	
	Negatively affected immune functions	
	Increased mortality	
Indirect Impact	Changes in feedstuff crop yields	Elevated CO_2 level
	Changes in pasture composition and forage production	
	Changes in forage quality	Increased temperature and elevated CO_2 level
	Shrinking water availability and increasing water use	Increased temperature
	Larger seasonal variation in resource availability	More frequent extreme climate events
	Increased disease, pest, and parasite stress	Increased temperature and changes in the precipitation pattern

Figure 2: Literature review outcome showing climate change impacts on livestock production[49].

In order to meet the emissions reduction target set by the EC, widespread strategies must set out pathways to reduce emissions across industries. The National Emission Reduction Commitments Directive sets emissions ceilings for five main types of emissions; ammonia, non-methane volatile organic compounds, nitrous oxide, fine particulate matter (PM2.5) and sulphur dioxide. According to the EEA, "...agriculture is responsible for some 94% of EU ammonia emissions, which has significant adverse effects on the natural environment and every year contributes to air pollution that causes the premature deaths of around 360,000 Europeans"[50]. Therefore, ammonia is one of the five gases selected for reduction efforts for the sake of air quality in the EU. The Commission notes that some of the gases also contribute to climate change, recognising this as a collective benefit of mitigation[51]. Some of the common policies and measures reported by member states for ammonia include tailored application of nutrients (manure or fertiliser), improvements in herd management and on-farm infrastructure, as well as animal waste management[52]. Overall, the Directive requires member states to report on their emissions ceilings, and to voluntarily share policies and measures implemented to adhere to these limits.

Further emissions from livestock include methane, a product of enteric ruminant fermentation. In the EU Strategy to Reduce Methane, the gas is identified as a key component in mitigating climate change. It is named as the second most potent greenhouse gas (GHG), second only to carbon dioxide. The EC claims that 40-53% of anthropogenic methane originates from agriculture, in particular from intensive production[53]. Since the first targeted methane reduction strategies, implemented in 1990, emissions from agriculture have fallen by approximately a fifth[54]. The EU has the Strategy to reduce methane emissions which suggests the following measures to reduce methane in agriculture; (1) tailoring animal

[49] Cheng, Muxi, Bruce McCarl, and Chengcheng Fei. "Climate change and livestock production: a literature review." *Atmosphere* 13, no. 1 (2022): 140.

[50] European Environmental Agency. "Transforming Europe's Food System - Assessing the EU Policy Mix." Publications Office of the European Union, 2022. https://doi.org/10.2800/295264.

[51] European Environment Agency. "National Emission Reduction Commitments Directive Reporting Status 2020," 2019.

[52] European Environment Agency. "National Emission Reduction Commitments Directive – Policies and Measures (PaMs) to Reduce Air Pollutants Emissions." Data set. EEA, June 28, 2019. https://www.eea.europa.eu/data-and-maps/dashboards/overview-of-compliant-air-pollution-policies.

[53] European Commission. "COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on an EU Strategy to Reduce Methane Emissions." Press release, 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0663.

[54] European Commission. "COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on an EU Strategy to Reduce Methane Emissions." Press release, 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0663.

diets to reduce enteric fermentation (using feed additives, changing feeding techniques), (2) improving herd management (managing fertility and health), and (3) improving manure management (use of anaerobic digestion)[55]. The document covers a number of different avenues of action, such as membership in the Thematic Working Group on Agriculture and the Climate and Clean Air Coalition. In addition, it describes the importance of monitoring and measuring progress in the reduction of this potent GHG. It also calls for a more holistic approach to GHG emissions on the whole, stating that synergistic European policy could result in more progress in mitigating air quality and climate impacts[56]. Yet, this strategy is not legally binding and thus does not strictly require action by Member States. The Effort Sharing Regulation (ESR) sets national emission targets per sector, including the agricultural sector, for each Member State. It includes some emissions and industries not covered by the EU Emissions Trading System. The ESR does not include non-carbon livestock related emissions such methane or nitrogen, instead refers to Regulation 2018/842 which calls for binding GHG emissions reduction commitments by Member States. Said regulation does not have explicit sections accounting for the livestock sector and while the risk of methane emissions has been established, at the time of publishing, there is no dedicated policy to regulate anthropogenic methane emissions.

The EU Nitrates Directive aims to protect European waters from nitrogen contamination from agricultural sources[57]. The legislation builds on the Water Framework Directive, both of which target water quality in the EU. The Directive's implementation measures for agriculture require member states to establish codes of good agricultural practices and limit manure application, alongside monitoring and assessing risks related to nitrate leaching[58]. Codes of good agricultural practice include manure management for livestock, the creation of buffer zones to prevent leaching and otherwise target arable farming by fertiliser application management. The Directive also sets an annual limit for manure application at 170 kg/ha in areas already polluted by nitrates, for which the Netherlands, Denmark and Germany have received exemptions[59]. The focus of this legislation is water quality, the potential for nitrogen reduction measures to deliver co-benefits in climate are not explicitly mentioned, although the protection of biodiversity (by preventing eutrophication) is.

The overall trend in EU legislation for GHG emissions is the omission of livestock in climate and environmental policy. The agricultural sector is included in a number of policies, but the focus is largely on fertiliser application and the overall use of synthetic inputs. Livestock as a key contributor to emissions in agriculture are mentioned in overarching statements and strategies such as in the Green Deal. But when it comes down to policy instruments and legislative frameworks, livestock is often an afterthought. Given that there is no dedicated livestock policy on the whole at the European level, there seems to be a disconnect between climate action and livestock's share in exceeding 1.5°C of warming. With nitrogen and methane emissions each respectively responsible for the exacerbation of global

[55] European Commission. "COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on an EU Strategy to Reduce Methane Emissions." Press release, 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0663.

[56] European Commission. "COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS on an EU Strategy to Reduce Methane Emissions." Press release, 2020. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020DC0663.

[57] European Commission. "Consolidated Text: Council Directive of 12 December 1991 Concerning the Protection of Waters against Pollution Caused by Nitrates from Agricultural Sources (91/676/EEC)." Press release. EUR-Lex, 2008. Accessed June 28, 2023. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01991L0676-20081211.

[58] European Commission. "Consolidated Text: Council Directive of 12 December 1991 Concerning the Protection of Waters against Pollution Caused by Nitrates from Agricultural Sources (91/676/EEC)." Press release. EUR-Lex, 2008. Accessed June 28, 2023. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A01991L0676-20081211.

[59] European Commission. "Nitrates." Accessed June 28, 2023. https://environment.ec.europa.eu/topics/water/nitrates_en#:~:text=by%20livestock%20production-,Law,50%20mg%2Fl%20of%20nitrates.

warming, air quality related mortality and the contamination of water, there is a clear need to manage sources of these pollutants.

2. *Diversity*

In the European policy literature on food systems, diversity is often said to contribute to resilience and sustainability[60,61,62,63] by creating buffers that absorb disruptions to the system that can reduce overall environmental impacts[64]. As the Cofund ERA-NET SusAn report notes, "The complexity of the European agri-food system means that livestock production is seen as a sub-system in a larger context"[65]. This larger context reinforces the importance of considering a systems thinking approach, meaning accounting for emergent properties. In other words, a system is more than the sum of its parts and should be governed accordingly[66]. This means that diversity encompasses a range of elements from consumption to economic or environmental considerations that impact the food system but also extend to all other sectors and inherently overlap. For example, within consumption diversity can relate to product offerings, nutritional profiles, or dietary preferences such as plant based, gluten free or halal. In economic terms, we might consider the length of supply chains, size and number of businesses present in the market, or the taxation for certain products such as meat or sugar. As for the environment, we might consider biodiversity expressed through genetic diversity, or the presence of local and indigenous species in the food chain or landscape on the whole[67]. Ultimately, the complexity of European production systems on the whole results in a 'one size does **not** fit all' approach to solving sustainability[6869] issues through policy.

As part of the European Green Deal, the Biodiversity Strategy sets out the importance of biodiversity for food security, ecosystem services, and livelihoods[70]. It establishes a headline mission to which the EU's measures will contribute, of achieving global ecosystem restoration, resilience and protection[71]. Overarching goals such as the protection of land, forests and the management of lands for the sake of

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60 European Commission. "Biodiversity Strategy." European Union, 2020. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

61 European Commission. "Farm to Fork Strategy." European Union, 2020. https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf.

62 OECD. *Agricultural Policy Monitoring and Evaluation 2021 Addressing the Challenges Facing Food Systems*. OECD Publishing, 2021.

63 Peyraud, Jean Louis, INRAE, Saggau, Elke, BLE, and Bassler, Arnd, BLE. "COMMON STRATEGIC RESEARCH AND INNOVATION AGENDA." *Https://Www.Era-Susan.Eu/Content/Susan%E2%80%99s-Common-Strategic-Research-and-Innovation-Agenda*. Cofund ERA-NET "Sustainable Animal Production Systems" (SusAn), February 2022.

64 De Schutter, Olivier. "Towards a Common Food Policy for the European Union." IPES-Food panel, 2019. http://www.ipes-food.org/pages/CommonFoodPolicy.

65 Peyraud, Jean Louis, INRAE, Saggau, Elke, BLE, and Bassler, Arnd, BLE. "COMMON STRATEGIC RESEARCH AND INNOVATION AGENDA." *Https://Www.Era-Susan.Eu/Content/Susan%E2%80%99s-Common-Strategic-Research-and-Innovation-Agenda*. Cofund ERA-NET "Sustainable Animal Production Systems" (SusAn), February 2022.

66 Peyraud, Jean Louis, INRAE, Saggau, Elke, BLE, and Bassler, Arnd, BLE. "COMMON STRATEGIC RESEARCH AND INNOVATION AGENDA." *Https://Www.Era-Susan.Eu/Content/Susan%E2%80%99s-Common-Strategic-Research-and-Innovation-Agenda*. Cofund ERA-NET "Sustainable Animal Production Systems" (SusAn), February 2022.

67 Peyraud, Jean Louis, INRAE, Saggau, Elke, BLE, and Bassler, Arnd, BLE. "COMMON STRATEGIC RESEARCH AND INNOVATION AGENDA." *Https://Www.Era-Susan.Eu/Content/Susan%E2%80%99s-Common-Strategic-Research-and-Innovation-Agenda*. Cofund ERA-NET "Sustainable Animal Production Systems" (SusAn), February 2022.

68 Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

69 ERFP. "ANIMAL GENETIC RESOURCES STRATEGY FOR EUROPE." European Regional Focal Point for AnGR, November 18, 2021.

70 European Commission. "Biodiversity Strategy." European Union, 2020. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

71 European Commission. "Biodiversity Strategy." European Union, 2020. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

biodiversity set by the strategy are displayed in Box 1. Natura 2000 areas are protected under European legislation and intended to preserve and promote the functioning of rare, high value and threatened species or habitats[72]. The targets established in the Biodiversity Strategy alongside the 18% of EU that is already protected under Natura 2000 premises[73] signals the importance of wild habitats and the protection of nature. Paradoxically, in the Biodiversity Strategy "...there is no requirement for Member States to have biodiversity restoration plans. There are not always clear or binding targets and timelines and no definition or criteria on restoration or on the sustainable use of ecosystems. There is also no requirement to comprehensively map, monitor or assess ecosystem services, health or restoration efforts."[74]. While ambitions to pursue biodiversity goals are repeated often, concrete incentives to actively integrate these into law are somewhat absent.

Box 1: Three main commitments set by the Biodiversity Strategy

In this exploration of EU livestock systems, the biggest risk for diversity is the loss of biodiversity. This is recognised at an EU level, with the Biodiversity Strategy stating that "Biodiversity loss and ecosystem collapse are one of the biggest threats facing humanity in the next decade".[75] A popular measure of biodiversity loss is expressed by the planetary boundaries, where the indicator is referred to as biosphere integrity[76]. Biosphere integrity is composed of two sub indicators: genetic and functional diversity. The former is measured through extinction rates, specifically extinction per million species-years[77]. The latter, functional diversity is measured by biodiversity intactness index (BII), which measures changes in population richness as a result of human impacts[78]. Genetic diversity can be seen as a proxy for

[72] European Commission. "Natura 2000," 2008. Accessed June 28, 2023. https://ec.europa.eu/environment/nature/natura2000/index_en.htm.
[73] European Commission. "Natura 2000," 2008. Accessed June 28, 2023. https://ec.europa.eu/environment/nature/natura2000/index_en.htm.
[74] European Commission. "Biodiversity Strategy." European Union, 2020. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en
[75] European Commission. "Biodiversity Strategy." European Union, 2020. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en
[76] Steffen, Will, Katherine Richardson, Johan Rockström, Sarah E. Cornell, Ingo Fetzer, Elena M. Bennett, Reinette Biggs et al. "Planetary boundaries: Guiding human development on a changing planet." *Science* 347, no. 6223 (2015): 1259855.
[77] Steffen, Will, Katherine Richardson, Johan Rockström, Sarah E. Cornell, Ingo Fetzer, Elena M. Bennett, Reinette Biggs et al. "Planetary boundaries: Guiding human development on a changing planet." *Science* 347, no. 6223 (2015): 1259855.
[78] Steffen, Will, Katherine Richardson, Johan Rockström, Sarah E. Cornell, Ingo Fetzer, Elena M. Bennett, Reinette Biggs et al. "Planetary boundaries: Guiding human development on a changing planet." *Science* 347, no. 6223 (2015): 1259855.

resilience, in that it can serve as a buffer for change in a system. Mace et al.[79], consider genetic diversity as a key component of "humanity's portfolio of biodiversity insurance" linking it to valuable ecosystem services as well as recognising the inability to predict which nodes in a system determine its prosperity[80]. This means that it is critical to protect genetic diversity on the whole instead of prioritising some species over others in hopes that they will carry more value in the future. According to the planetary boundaries in the context of agriculture, Campbell et al., claim:

> In the absence of better information, we suggest 80% as the role of agriculture in the status of the biosphere integrity PB, i.e., the same value as that for land-system change given that losses of both genetic and functional diversity loss are driven by land-system change. Thus agriculture has shifted biosphere integrity beyond the PB, at least for one of the components of this PB[81].

Looking specifically at the difference between genetic and functional diversity, genetic diversity has surpassed its safe operating space. The contribution of agriculture to the degradation of this status, according to Campbell et al.[82], is evident. Livestock's role in this has been disputed, both on the policy and scientific levels. Trade-offs between areas of concern such as greenhouse gases, animal health and welfare and diversity add to the complexity of assessing the benefits of intensive or extensive animal production. Livestock can be said to drive biodiversity loss, but also to reverse and conserve its status[83]. This is a prime example of where policy alignment can offer a solution. In establishing clear priorities and solutions through which to target issues such as biodiversity loss, enshrining these across different policies can bolster consistent efforts to mitigate risk. The findings of this thesis can help provide insight into areas where policy alignment is lacking, and therefore where agreement is needed.

Currently, European policy on diversity often promotes the protection of landscapes and habitats, and in a limited way extends to the role of genetic diversity in agriculture. With the Biodiversity Strategy claiming one of the biggest threats of the next decade is the loss of biodiversity and associated feedback loops, it is somewhat contradictory that formal legislation for agricultural biodiversity in the EU is rare. According to the European Environmental Agency (EEA), "Only 27% of species assessments have a good conservation status and 63 % indicate an unfavourable conservation status: 42% poor and 21% bad. The trends indicate that only 6% of species with an unfavourable conservation status show improvement, while 35% continue to deteriorate at EU level"[84]. On a livestock production level, The European Farm Animal Biodiversity Information System (EFABIS) indicator shows the high levels of risk of extinction for cattle, sheep, goats, pigs and chicken in the EU (See figure 3)[85]. According to the FAO, due to the intensification and homogenisation of the livestock sector, a significant number of

[79] Mace, Georgina M., Belinda Reyers, Rob Alkemade, Reinette Biggs, F. Stuart Chapin III, Sarah E. Cornell, Sandra Díaz et al. "Approaches to defining a planetary boundary for biodiversity." *Global Environmental Change* 28 (2014): 289-297.

[80] Mace, Georgina M., Belinda Reyers, Rob Alkemade, Reinette Biggs, F. Stuart Chapin III, Sarah E. Cornell, Sandra Díaz et al. "Approaches to defining a planetary boundary for biodiversity." *Global Environmental Change* 28 (2014): 289-297.

[81] Campbell, Bruce M., Douglas J. Beare, Elena M. Bennett, Jason M. Hall-Spencer, John SI Ingram, Fernando Jaramillo, Rodomiro Ortiz, Navin Ramankutty, Jeffrey A. Sayer, and Drew Shindell. "Agriculture production as a major driver of the Earth system exceeding planetary boundaries." *Ecology and society* 22, no. 4 (2017).

[82] Campbell, Bruce M., Douglas J. Beare, Elena M. Bennett, Jason M. Hall-Spencer, John SI Ingram, Fernando Jaramillo, Rodomiro Ortiz, Navin Ramankutty, Jeffrey A. Sayer, and Drew Shindell. "Agriculture production as a major driver of the Earth system exceeding planetary boundaries." *Ecology and society* 22, no. 4 (2017).

[83] Kok, A., E. M. de Olde, I. J. M. de Boer, and R. Ripoll-Bosch. "European biodiversity assessments in livestock science: A review of research characteristics and indicators." *Ecological Indicators* 112 (2020): 105902.

[84] European Environment Agency. "State of Nature in the EU - Results from reporting under the nature directives 2013-2018." Publications Office of the European Union, 2020. https://www.eea.europa.eu/publications/state-of-nature-in-the-eu-2020.

[85] FAO. "Domestic Animal Diversity Information System (DAD-IS)." Data set, n.d. https://www.fao.org/dad-is/regional-national-nodes/efabis/en/.

domesticated breeds are at risk of extinction[86]. As diversity in domesticated systems can allow for resilience, this is a threat to current and future production challenges[87].

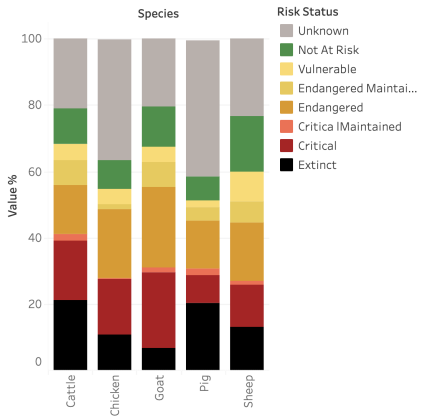

Figure 3: EFABIS Indicator for risk of EU breeds of cattle, sheep, goats, pigs and chicken[88].

Additional metrics and indicators for biodiversity in livestock production conditions are limited to genetic resource management. Overarching policies such as the Farm to Fork and Biodiversity Strategy note the importance of (bio)diversity and the need to conserve and sustainably use genetic resources[89]. The majority of policies on genetic resources home in on plant species, whereas animal genetic material is typically underrepresented. There are two approaches to conserving animal genetic resources, 'in situ' and 'ex situ' conservation. According to the European Regional Focal Point for Animal Genetic Resources (ERFP), the Union has relatively well developed in situ conservation programs for some breeds, which involve livestock production environments such as on farm or in breeding operations[9091]. ERFP does note that the programs need to extend to include more species. Ex situ conservation on the other hand is underutilised in the EU, meaning gene preservation by cryogenic or zoological parks occurs less often than in on farm or situ conservation[92]. A balance of the two conservation practices intends to contribute to the overarching objectives for animal genetic resources; conservation and sustainable use. The 'sustainable use' of genetic material "refers to ensuring genetic improvement while at the same time maintaining genetic diversity in sustainable breeding programs, as expressed in the phrase "conservation by (sustainable) utilisation"."[93]. Essentially, the maintenance of different species is done through breeding programs. Diversity here is achieved by active and controlled management.

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86 Scherf, Beate D., and Dafydd Pilling. "The second report on the state of the world's animal genetic resources for food and agriculture." FAO, (2015).

87 Scherf, Beate D., and Dafydd Pilling. "The second report on the state of the world's animal genetic resources for food and agriculture." FAO, (2015).

88 FAO. "Domestic Animal Diversity Information System (DAD-IS)." Data set, n.d. https://www.fao.org/dad-is/regional-national-nodes/efabis/en/.

89 European Commission. "Biodiversity Strategy." European Union, 2020. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

90 GenRes Bridge Project Consortium, ECPGR, ERFP, and EUFORGEN. "Genetic Resources Strategy for Europe." European Forest Institute, 2021.

91 ERFP. "ANIMAL GENETIC RESOURCES STRATEGY FOR EUROPE." European Regional Focal Point for AnGR, November 18, 2021.

92 ERFP. "ANIMAL GENETIC RESOURCES STRATEGY FOR EUROPE." European Regional Focal Point for AnGR, November 18, 2021.

93 ERFP. "ANIMAL GENETIC RESOURCES STRATEGY FOR EUROPE." European Regional Focal Point for AnGR, November 18, 2021.

While the EU has legislation in place that targets genetic resources, such as conservation programs, policies tend to be limited to the overall data management aspect of said resources[9495]. This consists of monitoring, recording and making available information about the presence, frequency, and amount of genetic resources that exist[96]. These practices are closely associated with previously discussed conservation strategies, as documentation solidifies the potential to measure progress. Across Europe there are gene banks that aim to support ex situ conservation, the Nagoya Protocol and overarching FAO ambitions for diversity[97]. These regulations all concern data availability, accessibility and privacy of genetic resources. Yet, according to Leroy et al., (2019), the range of breeds included in these gene banks are insufficient and in addition, ERFP claims that regulations to promote and properly manage genetic data in banks are lacking across the EU[9899]. This means that both the necessary operational details as well as the intended diversity are missing from the genetic resources landscape in the Union.

The mention of efficiency appears frequently in the policy interventions for diversity in livestock systems. Many of the claims promoting breed diversity note the importance of breeding for efficiency, in part to bolster European food security, reduce environmental impacts and ensure economic viability for farmers[100]. In the Netherlands, the Holstein-Friesian breed makes up more than 90% of the national cow population[101]. While these are highly productive animals due to their dual purpose and high milk quality, the severe homogenization of the cattle sector leaves it vulnerable to shocks and is not in line with overarching biodiversity goals. Here it becomes evident that trade-offs are an integral part of building policy, for diversity it may be important to promote the use of other cow breeds such as 'Blaarkoppen', yet for productivity and farmer income it may be favourable to select the Holstein breed.

In terms of the knowledge characterisation of biodiversity, there are various limitations of the indicators used both on a European and global scale. The planetary boundaries take into account global rates of extinction and diversity, but Mace et al.[102] note that comparing across geographical scales brings uncertainty. Overall, the planetary boundary for biosphere integrity has a high level of uncertainty due to the heterogeneity of global production systems. Contextual differences and balances between species, habitats and weather does not allow for accurate comparison between systems[103]. The European indicators are limited in their application as there is only one for livestock (EFABIS), the EU Habitats Directive which protects mostly wild animals and the others exclusively measure birds and

94 European Parliament and the Council. "Regulation (EU) 1151/2012 on Quality Schemes for Agricultural Products and Foodstuff," 2012. https://eur-lex.europa.eu/eli/reg/2012/1151/oj.

95 European Parliament and the Council. "Regulation (EU) No 511/2014 of the European Parliament and of the Council of 16 April 2014 on Compliance Measures for Users from the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from Their Utilization in the Union," 2014. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32014R0511.

96 European Parliament and the Council. "Directive 98/44/EC on the Legal Protection of Biotechnological Inventions," 1998. https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:31998L0044&from=FR.

97 Regional Focal Point for Animal Genetic Resources. "What Is EUGENA," n.d. https://eugena-erfp.net/en/about/what-is-eugena.

98 Leroy, Gregoire, Paul Boettcher, Badi Besbes, Coralie Danchin-Burge, Roswitha Baumung, and Sipke J. Hiemstra. "Cryoconservation of animal genetic resources in Europe and two African countries: a gap analysis." *Diversity* 11, no. 12 (2019): 240.

99 ERFP. "ANIMAL GENETIC RESOURCES STRATEGY FOR EUROPE." European Regional Focal Point for AnGR, November 18, 2021.

100 ERFP. "ANIMAL GENETIC RESOURCES STRATEGY FOR EUROPE." European Regional Focal Point for AnGR, November 18, 2021.

101 van Breukelen, Anouk E., Harmen P. Doekes, Jack J. Windig, and Kor Oldenbroek. "Characterization of genetic diversity conserved in the gene bank for Dutch cattle breeds." *Diversity* 11, no. 12 (2019): 229.

102 Mace, Georgina M., Belinda Reyers, Rob Alkemade, Reinette Biggs, F. Stuart Chapin III, Sarah E. Cornell, Sandra Díaz et al. "Approaches to defining a planetary boundary for biodiversity." *Global Environmental Change* 28 (2014): 289-297.

103 Mace, Georgina M., Belinda Reyers, Rob Alkemade, Reinette Biggs, F. Stuart Chapin III, Sarah E. Cornell, Sandra Díaz et al. "Approaches to defining a planetary boundary for biodiversity." *Global Environmental Change* 28 (2014): 289-297.

butterflies[104]. Many of the other indicators that are somehow related to biodiversity consider land use or land use change, urban expansion or the fragmentation of habitats by human practices other than livestock farming. As these do not fall within the scope of this paper, they will not be considered relevant measures of biodiversity for a future of sustainable livestock production in the EU.

3. Economy

Economics and the environment are inherently intertwined and should not be separated from one another. The economy depends on ecological functioning, the availability of resources and the governance of said systems. Therefore, as Anderies and John M et al.[105] write "The skeleton for sustainability is the recognition that a functioning biosphere is a precondition for economic and social development". That is to say, there is no economy without a biosphere. In a livestock context, the economy depends on synergies between trade flows, climatic conditions, and overall livestock management (e.g. veterinary medicine use). In a European livestock context, the diversity of production systems plays a significant role in the distribution of income, trade and rural development in the Union. Accordingly, the agricultural policies on a member state level diverge in line with national and/or regional priorities[106].

Farmer incomes and profitability in livestock production diverge significantly across the union. In Romania in 2018, the income per annual work unit (AWU) was around 5,000 euros. In stark contrast, the AWU in Denmark during the same period was around 85,000 euros[107]. These large ranges are in part due to differences in margins, herd sizes and yields, further reaffirming the diversity of European production systems. Overall, these incomes contribute to local, regional and national economies, notwithstanding the contribution of the livestock sector to the European economy as a whole. According to Eurostat, in 2021 the EU exported over 195 billion euros worth of agricultural products. Animal products made up 22% of this, therefore the livestock sector generated over 40 billion euros from exports alone[108]. Given the significant contribution of the sector to EU incomes, both on national and union levels, protecting and improving the financial integrity of the industry is a key component of its survival.

The CAP is largely a financial instrument through which to support farm activity and rural development in the EU. In 2021, the CAP made up over a third of the EU-27 budget making it the Union's largest budgetary allocation[109]. Direct payments are considered the backbone of this piece of legislation, financing farmers according to per hectare, sustainable practices, or young farmer support[110]. According to Vinci (2022), "...on average, dairy farmers' income is reliant on CAP payments for about 70%, and beef farmers' for more than 100 %". In addition, the CAP includes voluntary coupled support, in which specific sectors or product categories can be targeted in order to avoid the collapse or abandonment of

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[104] European Environment Agency. "State of Nature in the EU - Results from reporting under the nature directives 2013-2018." Publications Office of the European Union, 2020. https://www.eea.europa.eu/publications/state-of-nature-in-the-eu-2020.

[105] Anderies, John M., Carl Folke, Brian Walker, and Elinor Ostrom. "Aligning key concepts for global change policy: robustness, resilience, and sustainability." *Ecology and society* 18, no. 2 (2013).

[106] OECD. *Agricultural Policy Monitoring and Evaluation 2021 Addressing the Challenges Facing Food Systems*. OECD Publishing, 2021.

[107] European Union. "EU Dairy Farms Report," EU-FADN, 2021.

[108] Eurostat. "Extra-EU Trade in Agricultural Goods." European Commission, 2023. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Extra-EU_trade_in_agricultural_goods#EU_trade_in_agricultural_products:_surplus_of_.E2.82.AC43_billion.

[109] Padilla Olivares, Francisco. "The EU's Expenditure." *Fact Sheets on the European Union*, March 2023.

[110] CLAUDIA, VINCI. "European Union beef sector: Main features, challenges and prospects." (2022).

production[111]. The voluntary coupled support scheme is a primary contributor to the beef and veal sector and in 2022, 22 Member States allocated support to the sector through this mechanism[112]. The financial support the CAP offers through subsidies and other instruments keeps the livestock sector afloat. Without these payments, livestock farmers could not continue to produce profitably.

Historically, the CAP was established to promote increased production to feed and stabilise a post-war Europe. Over time this led to excesses that became 'butter mountains' and 'wine lakes', prompting the Commission to implement quotas[113]. More than 30 years after its initial implementation, direct income support and environmental protection was integrated into the policy. The MacSherry reforms (1992) provided direct income support according to land area or livestock heads. These perverse incentives may be linked to a decrease in the number of farms paired with a clear increase in farm size and consolidation of agricultural businesses[114]. Over time, more attention has been paid to young farmers and succession, and the greening of the sector. The new CAP (2023-2027) provides member states with the opportunity to apply CAP premises to its own context, through Member State strategic plans. Each member state submits its agricultural plan according to the overarching CAP framework. Livestock interventions in these plans tend to adhere to a limited number of suggestions made by the union, and very few exceed commission standards, typically only in animal welfare. Boxes 2 & 3 show some of the specific measures, selected for their relevance to livestock, included in the most recent CAP eco schemes. While the introduction and adopting of eco schemes is a positive development in the lifespan of the CAP, with 25% of direct payments dedicated to eco schemes the remaining 75% are still dedicated to other potentially less sustainable practices[115].

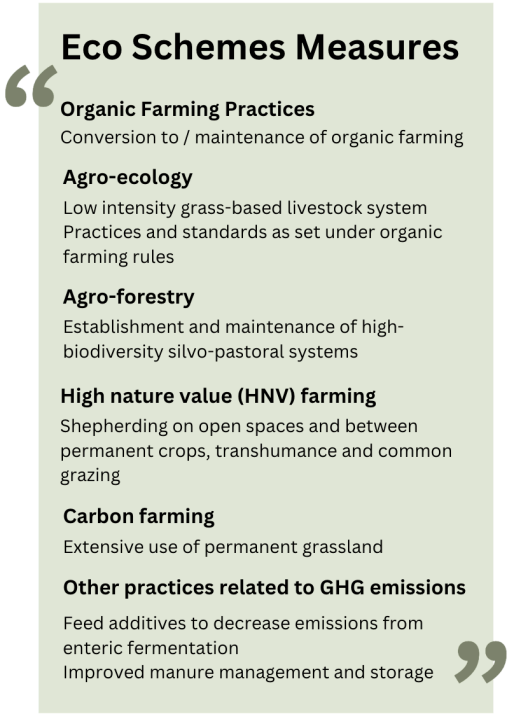
[111] European Commission. "Voluntary Coupled Support," n.d. https://agriculture.ec.europa.eu/common-agricultural-policy/income-support/additional-optional-schemes/voluntary-coupled-support_en.

[112] CLAUDIA, VINCI. "European Union beef sector: Main features, challenges and prospects." (2022).

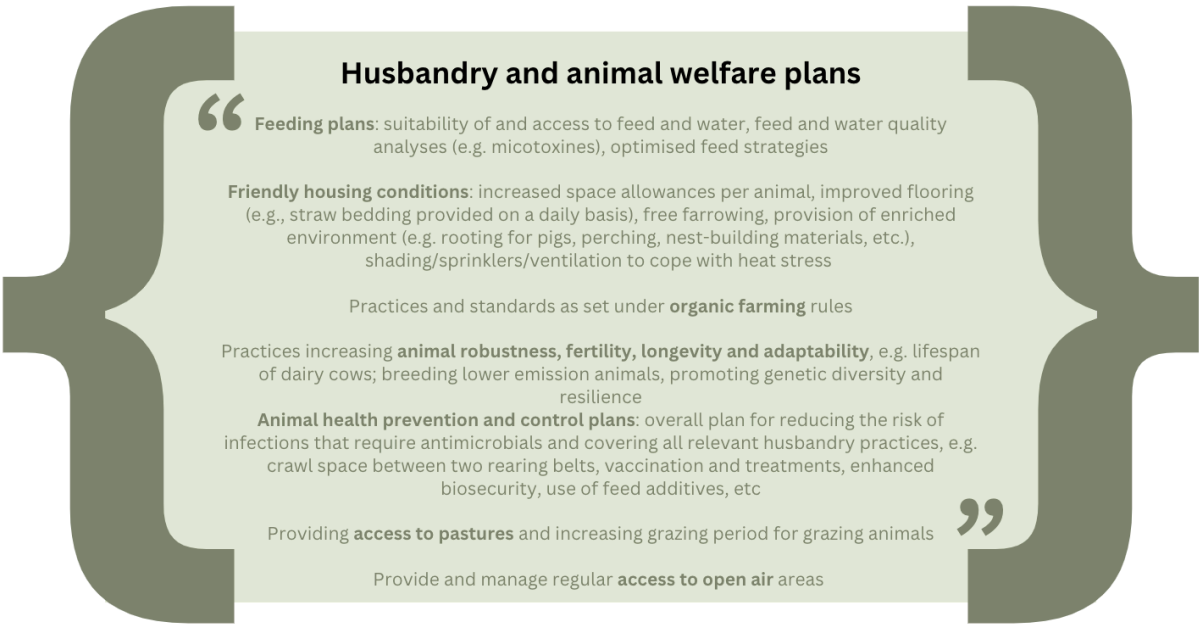
[113] European Council - Council of the European Union. "Timeline - History of the CAP," n.d. https://www.consilium.europa.eu/en/policies/cap-introduction/timeline-history/.

[114] Eurostat. "Farms and Farmland in the European Union-Statistics." (2019).

[115] European Environmental Agency. "Transforming Europe's Food System - Assessing the EU Policy Mix." Publications Office of the European Union, 2022. https://doi.org/10.2800/295264.



Box 2: Eco Schemes selected for relevance to livestock production[116].



Box 3: Eco Schemes selected for relevance to livestock production[117].

While these interventions demonstrate the recognition of livestock as a key area in need of management, some CAP strategic plans mention explicitly that there will be no sectoral interventions for beef/veal, milk and dairy, or sheep and goat products. According to a study by the EEA, there is a systematic lack

[116] "Commission Publishes List of Potential Eco-Schemes." European Commission, January 2021. https://agriculture.ec.europa.eu/news/commission-publishes-list-potential-eco-schemes-2021-01-14_en#moreinfo.
[117] "Commission Publishes List of Potential Eco-Schemes." European Commission, January 2021. https://agriculture.ec.europa.eu/news/commission-publishes-list-potential-eco-schemes-2021-01-14_en#moreinfo.

of emissions reduction actions and strategies in these strategic plans. In addition, myriad assessments by EU Member States paired with literature have established the negative impacts of intensive animal agriculture and yet there are no concrete instruments promoting the phasing out or reduction of such practices[118].

In reviewing the literature on the relationship between livestock production and the economy, farmer incomes through CAP instruments, payments for greening as well as international trade flows were described. While there are many more dimensions to this, it seems that the ultimate concern here is how the transition to a sustainable livestock sector will be financed. Ultimately, the risk in these is whether farming can provide a living wage in addition to promoting progress within the sector. Following this is whether this is the case for future generations hoping to continue to farm. Part of the transition to a more sustainable society requires investment[119]. Investment in technology, education, training and the like. Yet the question of who will bear the costs of this step remains largely unanswered, both on a European and Member State level. While market flows, international demand and regulations determine to a large extent whether farmers make a profit or not, this review cannot account for international trade flows and demand outside of Europe. The economic risk of financial collapse of the sector will only apply to livestock farmers in the EU-28 countries. To reinforce this, the main financial instrument that will be accounted for in this is the CAP. The future of the economic viability of the livestock sector depends largely on the ability of the CAP to sufficiently allocate funds to transition needs and sustainable development while accounting for other EU expenditures. That is, given the CAP already makes up a third of the EU budget, how can costs be covered without compromising the functioning of other sectors?

In line with the need to fund the transition, there is a gap in the distribution of responsibility. The financial, social and governance accountabilities associated with livestock production need to be covered by relevant stakeholders. The polluter pays principle could be an example of a distribution of responsibility. In 2018, the Netherlands implemented a system for trading phosphate rights. The legislation sets out a cap on phosphate production per farm according to cattle heads. If farmers exceed this cap they can trade rights on the market, or reduce their herd size[120]. Since its implementation, the phosphate levels from manure have decreased and now sit below the European production ceiling[121]. This offers an example of the valuation of environmental damages, an attempt to internalise externalities. Yet, here the costs are to be covered by farmers with no concrete plan on how to aid the financial investment required to produce sustainably according to ever changing standards. Not only is there a lack of policy for the financial costs of transitioning livestock production for farmers, this extends to consumers as well. Overall, at the EU level there is consensus that the food system needs to operate more sustainably but the financial support for this is absent.

4. Consumption

One of the main stakeholders in the food industry is consumers, in the scope of this review that is the EU populous. As the label ‘consumers’ accounts for those who purchase foodstuffs from supermarkets,

[118] European Environmental Agency. “Transforming Europe’s Food System - Assessing the EU Policy Mix.” Publications Office of the European Union, 2022. https://doi.org/10.2800/295264.

[119] World Bank. "Opportunities for Climate Finance in the Livestock Sector: Removing Obstacles and Realizing Potential." (2021).

[120] European Commission. “State Aid: Commission Approves Introduction of Tradable Phosphate Rights for Dairy Cattle in the Netherlands.” *European Commission Presscorner*, December 2017. https://ec.europa.eu/commission/presscorner/detail/en/IP_17_5362.

[121] Centraal Bureau voor Statistiek. “Lower Nitrogen and Phosphate Output from Animal Manure.” *CBS Statistics Netherlands*, February 16, 2022. https://www.cbs.nl/en-gb/news/2022/07/lower-nitrogen-and-phosphate-output-from-animal-manure.

restaurants and distributors. Consumption in the EU is influenced by a range of factors including cost of food, consumer willingness to pay, preference, food safety, nutrition, and increasingly transparency and labelling. Across European policies and strategies the quality of European foodstuffs is said to be high, oftentimes higher than products from non-EU origins. This is often translated into labelling in consumer-facing products such as meat or dairy. The increasing popularity of animal welfare, organic, and other labels such as DOP appeal to the growing influence of consumer preferences and their willingness to pay for niche products[122]. Labels have been associated with improved environmental and health awareness among consumers. The Farm to Fork strategy recognises the importance of consumer preferences, naming it as an opportunity for improvements in food standards[123]. The EU Agricultural Outlook 2021-2031 predicts that nutrition will drive the demand for dairy products and meat products, driving down demand for the latter. In addition, sustainability will likely play a role in European demand for beef products[124].

The biggest long term risk related to the consumption of animal products in the EU is the prevalence of diseases of affluence such as cancer, obesity, and cardiovascular disease. The reason for this risk instead of food insecurity is that according to the Global Food Security Index, 8 of the top 10 most food secure countries in the ranking are European[125]. This ranking accounts for affordability, quality and safety, availability, and sustainability and adaptation. While there is a broad range of food (in)security across the union, overall EU member states rank high in the index, indicating insecurity is currently not a prime risk. Granted, vulnerabilities in the supply chain can change this. External shocks like commodity prices, geopolitical unrest and extreme climatic events have the potential to create food insecurity in the EU. But, for the sake of this research, the health and nutritional aspects of ASF incur risk.

While the evidence for the health impacts of ASF is widely contested, there is a mounting body of research on the impact of the consumption of red and processed meats on human health. A number of institutions have linked these products to the development of cancer, and the WHO recommends limiting meat consumption, in particular red and processed meats[126]. In addition, increased rates of consumption of processed, energy-dense and nutritionally lacking foods characterises the current European food environment[127]. With high rates of obesity and the role obesity plays in causing various types of cancer the threat to public health is evident. The WHO reports that no member states are currently on track to reaching a reduction in the rise of obesity in Europe[128]. While links have been made between the consumption of (processed) animal products, the evidence is inconclusive and uncertain. Moreover, the nutritional benefits of animal products such as their micronutrient richness can supply important components of a balanced diet. Animal products are particularly high in calcium, vitamin B12, omega fatty acids and other key compounds required for human health and development. The Lancet proposes a diet that prioritises both planetary and human health outcomes, describing this

[122] European Parliament and the Council. “Regulation (EU) 1151/2012 on Quality Schemes for Agricultural Products and Foodstuff,” 2012. https://eur-lex.europa.eu/eli/reg/2012/1151/oj.

[123] European Commission. “Farm to Fork Strategy.” European Union, 2020. https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf.

[124] EC. "EU Agricultural Outlook for Markets, Income and Environment, 2021–2031." (2021).

[125] Economist Impact and Corteva Agriscience. “Global Food Security Index 2022.” The Economist Group. Data set, 2022. https://impact.economist.com/sustainability/project/food-security-index/.

[126] Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

[127] World Health Organization. *WHO European regional obesity report 2022*. World Health Organization. Regional Office for Europe, 2022.

[128] World Health Organization. *WHO European regional obesity report 2022*. World Health Organization. Regional Office for Europe, 2022.

as a diet low in animal products and processed foods while favouring plant-based foods[129]. While the EU Agricultural Outlook 2021-2031 predicts that consumption of beef in the EU will fall, demand for poultry, sheep and goat is likely to increase[130]. Consumption of animal protein in Asia, which makes up 47% of global meat consumption, however, is increasing[131]. But, consumption in this context applies to European consumers and although it is important to note the complexity and influence of these interconnected systems, demand and impacts on health outside of the EU 27 bloc will not be accounted for in this section.

According to Eurostat, "more than half of the EU population is overweight and every sixth person is obese"[132]. As a metric used to express health, this reflects poorly on the state of health and nutrition among consumers in the Union. While animal protein consumption in Europe is expected to decline, the Union has not established any concrete legislative instruments to put this into motion. The recent European Green Deal, including the Farm to Fork strategy, does not definitively include meat consumption or animal protein consumption related to health in its overarching goals. The Farm to Fork, as the clearest EU strategy attempting to link food production to consumption, makes a very limited contribution to health and nutrition recommendations. It suggests national governments should apply low VAT additions to 'healthy foods' (fruits and vegetables) and add premiums to 'unhealthy foods' (ultra-processed products)[133]. A consideration for the future of the consumption of animal products is the role an institution like the Commission can play in dietary recommendations. The Farm to Fork Strategy as well as the EU's new Cancer Plan target food marketing and plan to regulate the marketing of foods associated with higher cancer risk[134]. In addition, these documents promote shifting to a more plant-based diet, yet EU statements currently do not explicitly promote a reduction in meat consumption. Approaches among stakeholders differ widely, it is not in the interest of livestock farmers for consumption to be reduced, the financial contribution the livestock sector supplies for the Union may be a driver for the Commission to refrain from advising a clear reduction.

In terms of the policy concerning consumption, the vast majority centres around labelling and transparency of foodstuffs. The high standard of quality and in turn labelling in the union is a point that surfaces often in the contextualisation of the food industry. Labelling and transparency in food is considered to improve the sustainability and environmental impact of the industry. In part, this is because labelling is typically targeted at consumers. In particular, the EU Regulation on quality schemes for agricultural products and foodstuffs highlights the intended influence of labelling and transparency: "...thereby ensuring: (a) fair competition for farmers and producers of agricultural products and foodstuffs having value-adding characteristics and attributes; (b) the availability to consumers of reliable information pertaining to such products (c) respect for intellectual property rights; and (d) the integrity of the internal market"[135]. These outcomes span a range of considerations, yet do not explicitly separate plant and animal products or production.

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[129] Willett, Walter, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett et al. "Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems." *The lancet* 393, no. 10170 (2019): 447-492.

[130] EC. "EU Agricultural Outlook for Markets, Income and Environment, 2021–2031." (2021).

[131] Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

[132] Eurostat. "Sustainable Development in the European Union: Monitoring Report on Progress towards the SDGs in an EU Context." Publications Office of the European Union, 2023. https://doi.org/10.2785/403194.

[133] European Environmental Agency. "Transforming Europe's Food System - Assessing the EU Policy Mix." Publications Office of the European Union, 2022. https://doi.org/10.2800/295264.

[134] European Commission. "Europe's Beating Cancer Plan." September 2021. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/promoting-our-european-way-life/european-health-union/cancer-plan-europe_en.

[135] European Parliament and the Council. "Regulation (EU) 1151/2012 on Quality Schemes for Agricultural Products and Foodstuff," 2012. https://eur-lex.europa.eu/eli/reg/2012/1151/oj.

The literature review found that labelling for animal source foods is biased towards traceability and welfare standards. In line with the structure of this thesis, this section will not go into detail on animal health and welfare, but instead focus on the human health application of traceability and labelling. The General Food Law is a piece of policy prioritises the protection of human health and the interests of consumers, while including livelihoods, trade and animal health[136]. The main concern here is food safety. The law accounts for each stage of the food supply chain, establishing the need for policies and transparency from feed to water use, from GMOs to the transport of food. For livestock the scope includes chiefly feed (additives and origins) but also transport conditions and traceability[137]. Traceability in particular is oriented towards the food safety concerns associated with animal products. Many legislative pieces delve into pathogens prevalent in animal production, the risk of zoonoses, antibiotic or other medicinal use. For example, the Animal Breeding Regulation among others calls for the registration, documentation and labelling of the origin, treatment and breeding program associated with the farm animal. Ultimately the purpose of these regulations is to protect consumers that choose to consume animal source foods against disease and contamination. Overall, consumer-facing policy that focuses on labelling and traceability is mostly concerned with food safety rather than the nutritional integrity of animal source foodstuffs available in Europe.

5. Animal Health & Welfare

Animal health and welfare is closely interlinked with consumption, as the EU framing of these issues often follows the premise of food safety. Evidence of this can be found in the numerous policies that mention the One Health approach, or call for labelling and transparency in food chains over consumer health concerns. The legislation for animal health and welfare can be broadly broken down into the following categories (1) disease treatment and prevention, (2) the management of drugs (not including antibiotics), (3) feed influence on health and efficiency, (4) welfare in living, transport and slaughter conditions, (5) zoonoses and (6) labelling and traceability. While these categories make distinctions between kinds of legislation, there are many overlaps between the six, again confirming the interdisciplinary nature of policy. Ultimately, this is based on the 'One Health' approach, which forms a baseline for many policies and initiatives across the globe[138]. It links public, animal and environmental health to one another as intrinsically interdependent. Policy related to traceability, animal health, feed ingredients and the like are all in some way linked to consumers through food safety. Several landmark EU documents name food safety as one of the pillars of the European food system, as something that is expected from the Commission and other institutions responsible for regulation and monitoring of foodstuffs. In turn the biggest risks for animal health and welfare are due to the run on effects on consumers. Specifically, the risk of disease outbreak in livestock production sites as well as the accumulation of antibiotic resistance.

The risk in this category can thus be measured by the prevalence of foodborne zoonotic diseases originating or amplified in and by livestock production sites. Most of the contamination risks identified by EFSA are directly related to animal production, for example animal feed or milk that has been

[136] European Parliament and the Council. "Regulation (EU) 178/2002 laying down the general principles and requirements of food law, establishing the European Food SafetyAuthorityand laying down procedures in matters of food safety," 2002. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002R0178&from=EN

[137] European Parliament and the Council. "Regulation (EU) 178/2002 laying down the general principles and requirements of food law, establishing the European Food SafetyAuthorityand laying down procedures in matters of food safety," 2002. https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002R0178&from=EN

[138] World Health Organization. "One Health." *WHO Newsroom*, 2017. https://www.who.int/news-room/questions-and-answers/item/one-health.

contaminated by bacteria, or meat contaminated during slaughter[139]. Prevalence of said diseases includes the type, transmission, and severity of a disease. Foodborne zoonotic diseases caused by bacteria of animal origin such as Campylobacter, Salmonella, Yersinia, E. coli and Listeria are known for their detrimental impacts on humans. Campylobacteriosis and salmonellosis reportedly infected over 180,000 Europeans in 2021[140]. Depending on the type of foodborne zoonotic disease a consumer was infected with, hospitalisation rates ranged from 22% for Campylobacteriosis to over 90% for Listeriosis[141]. The WHO estimates that 23 million Europeans are affected by foodborne illnesses each year. This signals that a clear threat is posed by ASF in its contribution to ill health in humans.

These consequences are magnified by antimicrobial resistance (AMR), which has been linked to excessive use of antimicrobials in livestock. Resistance and mutations in Salmonella and Campylobacteriosis as well as other microorganisms such as E. coli are linked to the use of antimicrobials, thus limiting treatment options in both animals and humans[142]. The combined risk of foodborne illnesses and AMR amplify food safety concerns, threatening one of the main pillars of the European food system. AMR has been classified by the WHO as one of the top 10 threats to global human health. In addition, the European Centre for Disease Control (ECDC) also recognises AMR as a global threat, and claims that it is currently insufficiently managed at the European level. The organisation describes AMR as an underfunded and inadequately monitored issue that causes over 670,000 yearly infections in Europe alone[143]. This number cannot account for the lack of self-reporting or self-treatment conducted by citizens who did not visit a hospital or seek formal treatment. In order for a case to be integrated into official statistics, steps must follow an order: person becomes ill, they seek treatment, a sample is extracted, a lab test is conducted, a case of illness can be confirmed and finally is documented and reported[144]. More often than not this process is not completed, resulting in uncertain statistics.

Those bearing the responsibility for the monitoring, regulation and management of foodborne zoonoses and antibiotic resistance include food producers, processors, farmers, and regulatory agencies/institutions such as the EFSA or the EC. Each stage of the food supply chain comes with its own considerations for food safety, such as cleanliness in slaughterhouses or the health of individuals handling food items in a kitchen. Within the EEA, the cooperation of all these stakeholders is essential in achieving true food safety. Activities outside of the Union are outside of the scope of this analysis, including only import regulations for labelling and transparency.

With increasing industrialisation and intensification in animal farming, the conditions under which farmed animals live may give rise to threats to both human and animal health. In intensive farming operations, animals are often kept in close confinement in high numbers, are fed homogenous diets, and are administered a range of preventative medicines. Compared to outdoor or wild animal farming, "Intensive farming may reduce the likelihood of pathogen introduction through biosecurity intervention but significantly increases the risks of amplification, spread and the mutation of pathogens once they

[139] European Food Safety Authority. "Foodborne Zoonotic Diseases," n.d. https://www.efsa.europa.eu/en/topics/topic/foodborne-zoonotic-diseases.

[140] European Food Safety Authority, and European Centre for Disease Prevention and Control. "The European Union One Health 2021 Zoonoses Report." *EFSA Journal* 20, no. 12 (2022): e07666.

[141] European Food Safety Authority, and European Centre for Disease Prevention and Control. "The European Union One Health 2021 Zoonoses Report." *EFSA Journal* 20, no. 12 (2022): e07666.

[142] European Food Safety Authority, and European Centre for Disease Prevention and Control. "The European Union One Health 2021 Zoonoses Report." *EFSA Journal* 20, no. 12 (2022): e07666.

[143] World Health Organization. "Antimicrobial resistance surveillance in Europe 2022–2020 data." (2022).

[144] World Health Organization. "Antimicrobial resistance surveillance in Europe 2022–2020 data." (2022).

enter farming facilities."[145]. Essentially, high density confinement conditions can act as a site where diseases can rapidly spread and mutate. This can decimate livestock populations, impacting farmer income and food supply. African Swine Fever is a prime example of this, from 2016-2020 approximately 8 million animal losses across the globe were reported due to infection with ASF[146]. With an almost 100% mortality rate, Avian influenza, which is currently affecting over 50 million birds in the US, poses a similar threat[147].

A crucial threat to animal husbandry, but also human health, that mounts with the expansion of industrial farming and proximity to wild animals, is zoonoses. Zoonotic spillover and ensuing pandemics have been identified as a significant threat to society[148]. The expansion of human activity into wild spaces has been linked to increasing risk of zoonotic spillover. Proximity to wild animals and their pathogens, in addition to a loss of biodiversity by homogenization of landscapes and species increases the likelihood of epidemics[149]. While the governance of land use is outside of the scope of this research, regulations that include farm animal health fall within the scope and are thus intertwined. The EU has a range of regulations concerning zoonoses, including but not limited to Campylobacter, Salmonella, Rabies, Yersinia and Tuberculosis[150]. These regulations lay out strict rules around monitoring, compliance, and hygiene measures to prevent the spread of zoonoses in the Union[151][152]. Closely associated with the One Health approach, the governance of zoonoses and other diseases is a clear priority in Europe.

In order to mitigate some of the risks associated with intensive farming, some farmers administer preventative antibiotics or other medicines. Antibiotics in particular are a contentious issue in the EU. The International Panel of Experts on Sustainable Food Systems (IPES) reports that "... the EU livestock sector consumes more antibiotics than the human medical sector, and is contributing to the spread of antimicrobial resistance, which accounts for 33,000 deaths per year in the EU."[153][154]. Legislation targeting veterinary medicines therefore often focuses on antibiotics. To situate the importance of this issue, the Farm to Fork strategy has a target to reduce the sale of antimicrobials for farmed animals by

[145] Espinosa, Romain, Damian Tago, and Nicolas Treich. "Infectious diseases and meat production." *Environmental and Resource Economics* 76, no. 4 (2020): 1019-1044.

[146] World Organisation for Animal Health. "Global Situation of African Swine Fever." World Animal Health Information Department, 2020.

[147] Animal and Plant Health Inspection Service - USDA. "2022-2023 Confirmations of Highly Pathogenic Avian Influenza in Commercial and Backyard Flocks," 2023. https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/avian/avian-influenza/hpai-2022/2022-hpai-commercial-backyard-flocks.

[148] Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

[149] Civitello, David J., Jeremy Cohen, Hiba Fatima, Neal T. Halstead, Josue Liriano, Taegan A. McMahon, C. Nicole Ortega et al. "Biodiversity inhibits parasites: broad evidence for the dilution effect." *Proceedings of the National Academy of Sciences* 112, no. 28 (2015): 8667-8671.

[150] European Food Safety Authority, and European Centre for Disease Prevention and Control. "The European Union One Health 2021 Zoonoses Report." *EFSA Journal* 20, no. 12 (2022): e07666.

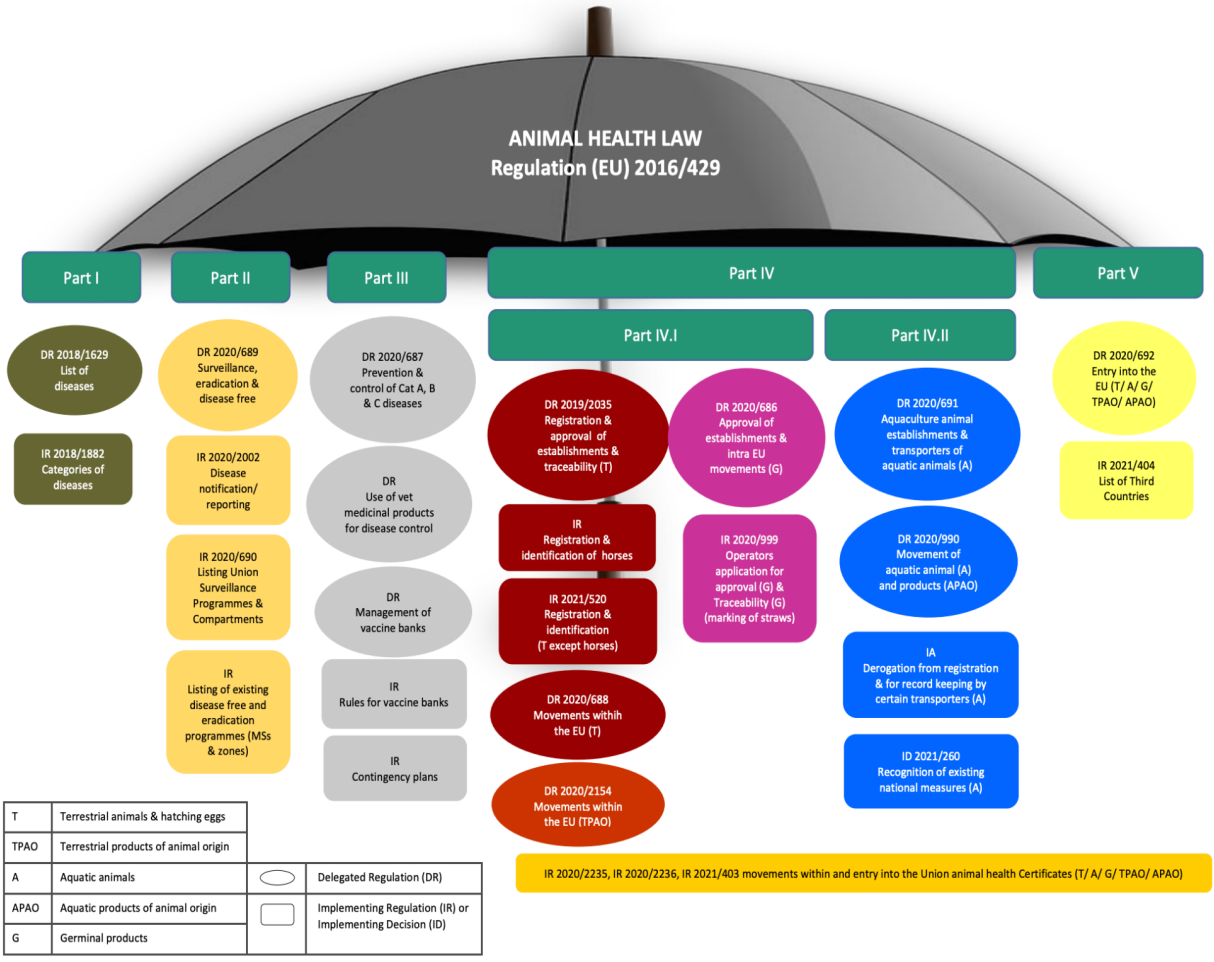
[151] European Parliament and the Council. "Regulation (EU) 2073/2005 on microbiological criteria for foodstuffs," 2005. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32005R2073

[152] European Parliament and the Council. "Regulation (EU) 2003/99 on the monitoring of zoonoses and zoonotic agents, amending Council Decision 90/424/EEC and repealing Council Directive 92/117/EEC," 2003. https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32005R2073

[153] De Schutter, Olivier. "Towards a Common Food Policy for the European Union." IPES-Food panel, 2019. http://www.ipes-food.org/pages/CommonFoodPolicy.

[154] Cassini, Alessandro, Liselotte Diaz Högberg, Diamantis Plachouras, Annalisa Quattrocchi, Ana Hoxha, Gunnar Skov Simonsen, Mélanie Colomb-Cotinat et al. "Attributable deaths and disability-adjusted life-years caused by infections with antibiotic-resistant bacteria in the EU and the European Economic Area in 2015: a population-level modelling analysis." *The Lancet infectious diseases* 19, no. 1 (2019): 56-66.

50% by 2030[155]. A range of other regulations exist to control the use of antimicrobials, such as The Framework for Veterinary Medicinal Products Regulation which includes rules for the veterinary products markets, and establishes which antimicrobials are reserved for human purposes and which are to be used on animals[156]. In addition, the Animal Health Law focuses on health and safety in the agri-food chain, but in particular for diseases in animal production[157]. Figure 4 summarises the "...requirements for disease prevention, awareness, surveillance, control and eradication; biosecurity; traceability of animals and animal products; movements within the EU and entry into the EU of animals and animal products; as well as emergency measures."[158]. This law does not explicitly recognize animal welfare in its rules but does make a link between the two. While there are many other measures aimed at animal disease control, the Animal Health Law aimed to consolidate some of these and produce a comprehensive, cohesive piece of legislation.



[155] European Commission. "Farm to Fork Strategy." European Union, 2020. https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf.

[156] European Parliament and the Council. "Regulation (EU) 2021/1760 of 26 May 2021 supplementing Regulation (EU) 2019/6 of the European Parliament and of the Council by establishing the criteria for the designation of antimicrobials to be reserved for the treatment of certain infections in humans," 2021. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32021R1760

[157] European Commission. "About the Animal Health Law." Accessed June 28, 2023. https://food.ec.europa.eu/animals/animal-health/animal-health-law_en.

[158] European Commission. "About the Animal Health Law." Accessed June 28, 2023. https://food.ec.europa.eu/animals/animal-health/animal-health-law_en.

Figure 4: The components included in the Animal Health Law, all aiming to reduce or control diseases in livestock production in the EU[159].

The second overarching category in animal health and welfare legislation is the management of drugs (not including antibiotics). This encompasses the use of hormones and vaccinations. The use of hormones in farmed animals is regulated by Council Directive 96/22, which prohibits the use of substances that have a hormonal or thyrostatic effect on animals, as well as banning the sale of products with traces of said substances[160]. This regulation is concerned with the potential impacts of hormonal agents on human health, confirming the importance of food safety in European legislation. Moreover, Regulation 2022/429 sets out rules that aim to prevent and control animal diseases that are transmissible to humans[161]. It covers the composition and formulation, storage, delivery, and registration of vaccines to treat animal diseases. Overall, among other regulations, these govern what the Union refers to as 'biosecurity', the procedures by which to manage diseases in animals[162].

The third category consists of the impact of feed on animal health. In a targeted livestock context, the EU Feed Additives Regulation governs the composition of feed as it pertains to human and animal health and welfare. This regulation explicitly says it does not include veterinary medicinal products, but including coccidiostats and histomonostats as feed additives[163]. Broadly speaking, feed is often mentioned in mission and problem statements on EU and global levels due to the environmental impact of feed production. The impact of feed production on for example land use change is outside of the scope of this research, and as such no deforestation or land use policies will be reviewed. Although it is interesting to note that the EU has just passed a piece of legislation that aims to create a deforestation free supply chain that will likely have an impact on the livestock sector[164].

The fourth category, animal welfare, is well represented in European policy. The premise of almost all animal welfare regulation is the recognition of the sentience of animals, that is their capacity to feel pain and experience emotions. In the EU, animal sentience was recognized and enshrined in law in line with the Lisbon Treaty in 2009[165]. Europe's Convention for the Protection of Animals kept for Farming Purposes lays out the following freedoms: "(1) freedom from hunger and thirst, (2) freedom from discomfort, (3) freedom from pain, injury and disease, (4) freedom to express normal behaviour and (5) freedom from fear and distress"[166]. In line with this overarching framework, the EU has passed many more pieces of legislation which often concern welfare in housing, transport and slaughter conditions. Housing conditions include the space allocation per animal, access to light or the outdoors. In transport, rules account for temperature and stress during the journey. Recent EFSA recommendations include a

[159] European Commission. "About the Animal Health Law." Accessed June 28, 2023. https://food.ec.europa.eu/animals/animal-health/animal-health-law_en.

[160] European Parliament and the Council. "Regulation (EC) Council Directive 96/22/EC of 29 April 1996 concerning the prohibition on the use in stockfarming of certain substances having a hormonal or thyrostatic action and of ß-agonists, and repealing Directives 81/602/EEC, 88/146/EEC and 88/299/EEC," 1996. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A31996L0022

[161] European Parliament and the Council. "Commission Implementing Regulation (EU) 2022/140 of 16 November 2021 laying down rules for the application of Regulation (EU) 2016/429 of the European Parliament and of the Council with regard to the Union antigen, vaccine and diagnostic reagent banks," 2021. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32022R0140

[162] European Parliament and the Council. "The EU animal health law," 2016. https://eur-lex.europa.eu/EN/legal-content/summary/the-eu-animal-health-law.html#:~:text=It%20aims%20to%20prevent%20and,the%20entire%20agri%2Dfood%20chain

[163] European Parliament and the Council. "Regulation (EU) 1831/2003 of the European Parliament and of the Council of 22 September 2003 on additives for use in animal nutrition," 2003. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02003R1831-20210327

[164] European Commission. "Questions and Answers on New Rules for Deforestation-Free Products." EC Newscorner, 2021. https://ec.europa.eu/commission/presscorner/detail/en/qanda_21_5919.

[165] European Commission. "Animal Welfare." Food Safety, n.d. https://food.ec.europa.eu/animals/animal-welfare_en.

[166] European Commission. "Animal Welfare." EUR-Lex, n.d. https://eur-lex.europa.eu/EN/legal-content/glossary/animal-welfare.html.

more in depth, scientific exploration of animal welfare during transport, accounting for hunger, thirst, fatigue, and journey duration[167]. Welfare during slaughter or miscellaneous treatments is largely concerned with pain management and sedation. For example, the ban on male piglet castration without anaesthesia represents a recognition of the capacity for animals to feel pain and stress during an invasive intervention[168]. Furthermore, the Animal Breeding regulation sets out breeding and selection processes for animals. These rules have had an impact on animal production efficiency. Farmed animals in intensive settings are typically bred for efficiency, which has had detrimental impacts on welfare[169].

Due to its proximity to animal health, welfare is a topic of concern for research and policy in the EU. Welfare is included in the Farm to Fork and Biodiversity Strategy, but in a minimal way. Animal welfare is typically linked to animal health and the reduction of antibiotics and disease, which is in turn linked to food safety and consumers. Inclusion of ethical treatment or quality of life is limited. That said, the following eco schemes in the CAP target the improvement of animal welfare (1) "Friendly housing conditions: increased space allowances per animal, improved flooring (e.g., straw bedding provided on a daily basis), free farrowing, provision of enriched environment (e.g. rooting for pigs, perching, nest-building materials, etc.), shading/sprinklers/ventilation to cope with heat stress, (2) Practices and standards as set under organic farming rules, (3) Practices increasing animal robustness, fertility, longevity and adaptability, e.g. lifespan of dairy cows; breeding lower-emission animals, promoting genetic diversity and resilience, (4) Providing access to pastures and increasing grazing period for grazing animals and (5) Provide and manage regular access to open air areas"[170]. These interventions that can receive funding offer a balance of distinct health and welfare. Other policy initiatives include The EU Platform on Animal Welfare. The platform was established to further integrate animal welfare concerns throughout society, that is in business, governance, civil society, and science[171]. The Platform has subgroups on welfare labelling, pig welfare, and transport conditions. It organises initiatives that improve animal welfare, some of which extend beyond farmed animals to pets[172]. The care and quality of life of pets is outside of the scope of this research, policy accounted for will only encompass farmed land animals excluding aquaculture and fisheries.

The final animal health and welfare category broadly encompasses labelling and traceability, which is largely done for food safety purposes. Areas of importance of labelling include origin, mode of transport, conditions in which animals were raised and medicines used at any point. Many of the labelling requirements in the EU exceed international standards and thus hold products coming in and out of the Union to a specific standard. This can influence competitiveness within the Union, but also with exporters such as Mercosur who must adhere to EU legislation in order to engage in trade. Consumer accessibility to information about food safety and other qualities is a rising trend in the EU[173].

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[167] European Food Safety Authority. "More Space, Lower Temperatures, Shorter Journeys: EFSA Recommendations to Improve Animal Welfare during Transport." *EFSA*, September 7, 2022. https://www.efsa.europa.eu/en/news/more-space-lower-temperatures-shorter-journeys-efsa-recommendations-improve-animal-welfare.

[168] Mormede, Pierre, Lucille Boisseau-Sowinski, Julie Chiron, Claire Diederich, John Eddison, Jean-Luc Guichet, P. le Neindre, and Marie-Christine Meunier-Salaün. "Animal welfare: context, definition, evaluation." *INRA Productions Animales* 31, no. 2 (2018): 145-162.

[169] ERFP. "ANIMAL GENETIC RESOURCES STRATEGY FOR EUROPE." European Regional Focal Point for AnGR, November 18, 2021.

[170] Di Concetto, Alice. "Animals in the EU Agricultural Policy." European Institute for Animal Law & Policy, 2021.

[171] European Commission. "EU Platform on Animal Welfare," n.d. https://food.ec.europa.eu/animals/animal-welfare/eu-platform-animal-welfare_en.

[172] European Commission. "Platform Conclusions," n.d. https://food.ec.europa.eu/animals/animal-welfare/eu-platform-animal-welfare/platform-conclusions_en#pets.

[173] European Food Safety Authority. "Food Safety in the EU." European Commission, Directorate-General for Communication, 2019.

Consumers show increasing demand for animal welfare, quality, and environmental labels, in turn pushing legislation or businesses to respond.

6. Organic Agriculture

Organic agriculture is a very specific differentiator in this review. Since organic production is determined by a clear set of requirements, the corresponding legislation follows these guidelines closely. The rules for organic livestock production consider feed, veterinary medicines, GMOs and breeding. Antibiotics, the use of GMOs or conventional crops in the composition of feed for livestock is strictly forbidden under organic regulation. Animal welfare is considered an additional section for organic livestock in the EU, with rules encompassing grazing space and time, the use of containment, and the concentration of animals in production conditions[174]. Accordingly, all products to be labelled and sold as organic must be certified according to principles laid out in Regulation 2018/848 of the European Parliament[175]. Some of the objectives listed in this regulation include the protection of the environment and climate, to improving biodiversity, animal welfare, and promoting shorter supply chains in the EU[176]. It seems that the Commission suggests organic farming is an environmentally friendly way in which to diversify production systems within the EU. On a high level, this message is bolstered by the target set out in the Farm to Fork Strategy which is to "achieve at least 25% of the EU's agricultural land under organic farming and a significant increase in organic agriculture"[177]. In order to meet the 25% target, the commission calls on Member States to develop their own organic action plans and outline how national agricultural systems will contribute to the transition to more organic production[178].

In 2020, only 5% of European cattle herds were considered organic. So while arable farming has seen an increase of over 60% over the last 10 years, making up 8.3% of the total utilised agricultural area of the EU, livestock is still lagging behind[179]. Due to the conversion periods associated with switching from conventional to organic, it takes some time before farmers can officially label their products as organic and account for the price premium. Conversion times for livestock are as follows; 12 months for pig and poultry, 2 years for ruminants[180]. Bridging the income gap of supplying livestock with organic medicines and feed without the added price premium of the label may disincentivise farmers from making the switch. According to Kołoszko-Chomentowska and Stalgiene, there is a trend in European adoption of organic production that follows the availability of financial support[181]. As subsidies for supporting conversion to organic practices are made available, adoption is high. But as funding periods ended, across a 5 year period farmers in Slovakia and Germany abandoned organic and

[174] European Commission. "Organic Production and Products." Accessed June 28, 2023. https://agriculture.ec.europa.eu/farming/organic-farming/organic-production-and-products_en.

[175] European Parliament and the Council. "Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007," 2007. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02018R0848-20220101

[176] European Parliament and the Council. "Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007," 2007. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02018R0848-20220101

[177] European Commission. "Farm to Fork Strategy." European Union, 2020. https://food.ec.europa.eu/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf.

[178] European Commission. "Organic Action Plan," n.d. https://agriculture.ec.europa.eu/farming/organic-farming/organic-action-plan_en.

[179] European Commission. "Organic Action Plan," n.d. https://agriculture.ec.europa.eu/farming/organic-farming/organic-action-plan_en.

[180] European Commission. "Becoming an organic farmer," 2021. https://agriculture.ec.europa.eu/farming/organic-farming/becoming-organic-farmer_en

[181] Kołoszko-Chomentowska, Zofia, and Aldona Stalgiene. "Barriers to the development of organic farming." *Roczniki (Annals)* 2019, no. 1230-2020-806 (2019).

returned to conventional production[182]. This suggests the ability of funding to promote changes in production, but not necessarily the survival of the transition.

The main risk for organic production is the potential production and financial gaps incurred by a system that is not prepared to be 25% organic. While organic production can offer some environmental benefits due to its rejection of synthetic pesticides and fertilisers, as well as antibiotics, these benefits come with caveats. Fewer applications of nitrogen or phosphorus can reduce runoff and prevent eutrophication among other consequences such as groundwater contamination. The absence of antibiotics in organic production also reduces the risk of AMR and in turn the development of superbugs[183]. Having said this, it may also increase the risk of medicinal shortcomings given the lack of antibiotics and other medicines approved as organic. As organic livestock requires organic feed, the impacts of a conversion from conventional to organic would cause a shift in supply chains across Europe and other feed supplying countries. In addition, the financial burden of transitioning to organic without immediate returns may threaten the viability of livestock farming[184]. IFAD reinforces this notion, calling for more income support and additional CAP contributions to the funding for organic agriculture[185]. Ultimately, the goal of 25% of the EU under organic production is not within reach given the current contributions from Member States, thus failing to deliver on this aspect of sustainability.

The main policy for organic agriculture in the EU is the Organic Action Plan which is a pillar of the Green Deal through which the 25% area under organic target can be met. The Action Plan includes the following topics (selected by their relevance to livestock); (1) animal welfare, (2) feed considerations, (3) health and disease prevention, (4) genetic diversity, (5) labelling and transparency and (6) trade. Box 4 summarises the livestock-related measures listed in the Action Plan. Animal welfare measures include access to open air, housing conditions that allow for 'natural behaviours' and the reduction of stress. Feed encompasses investment into organic feed crop production but also the development of feed alternatives. Health and disease prevention promotes the adoption of alternative medicines to continue avoidance of antibiotics where possible. Genetic diversity stimulates the active use of genetic resource conservation through gene banks as well as promoting research into breeding practices. Labelling and transparency measures expand on the EU emphasis on the importance of these in building consumer trust, as well as the increasing interest in food labels for demand. Finally, trade is included by the expansion of trade agreements and financial support for the marketing of organics[186].

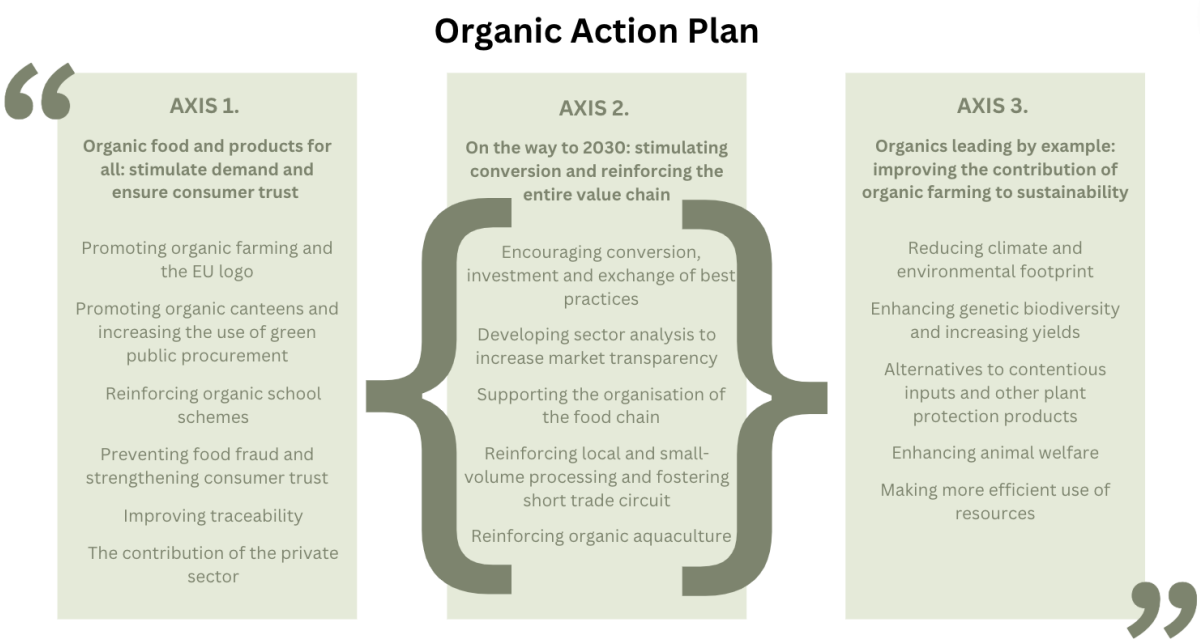
[182] Kołoszko-Chomentowska, Zofia, and Aldona Stalgiene. "Barriers to the development of organic farming." *Roczniki (Annals)* 2019, no. 1230-2020-806 (2019).

[183] World Health Organization. "Antimicrobial Resistance." *WHO Newsroom*, 2018. https://www.who.int/news-room/fact-sheets/detail/antimicrobial-resistance.

[184] Reganold, John P., and Jonathan M. Wachter. "Organic agriculture in the twenty-first century." *Nature plants* 2, no. 2 (2016): 1-8.

[185] Willer, Helga, Jan Trávníček, Claudia Meier, and Bernhard Schlatter. "The world of organic agriculture 2021-statistics and emerging trends." (2021): 1-336.

[186] European Commission. "Organic Action Plan," 2021. https://agriculture.ec.europa.eu/farming/organic-farming/organic-action-plan_en.



Box 4: actions proposed under the EU Organic Action Plan

To conclude this contextualisation of the issue, it is important to note that this is not an exhaustive report of all policy or risks in the EU concerning livestock. It is an attempt to consider the current policy and literature landscape in relation to sustainable livestock production. From this review it was found that animal health and welfare have the highest number of policies, with many different regulations on interventions using veterinary medicine in disease control. While sustainability is linked to livestock production, clear definitions and qualities of sustainable systems seem unclear. The One Health approach, linking public, animal and planetary health is scattered across the agriculture policy sphere, which may indicate a possible direction for livestock policy. It seems that there are some baseline priorities set for what a sustainable livestock policy may need to include, but at the time of writing no such framework or initiative exists at an EU level.

Analytic Framework

In order to guide the assessment of policy alignment, the International Risk Governance Framework developed for the International Risk Governance Council (IRGC) by a group of experts, will be used[187]. The Framework recognises the importance of the management of risk for decision-making and is widely applicable as it is not tied to a specific sector or industry. This review applies the Framework as guidance in structuring risk assessments. The following IRGC stages break down the complexities of risk in order to evaluate them.

The five stages consist of (1) pre-assessment, (2) appraisal, (3) characterisation and evaluation, (4) management and (5) cross-cutting aspects[188]. The figure below (Figure 4) summarises the IRGC

[187] Florin, Marie-Valentine, and Marcel Thomas Bürkler. *Introduction to the IRGC risk governance framework*. No. REP_WORK. EPFL, 2017.
[188] Florin, Marie-Valentine, and Marcel Thomas Bürkler. *Introduction to the IRGC risk governance framework*. No. REP_WORK. EPFL, 2017.

framework, showing each component of the risk governance assessment. While the IRGC has divided risk assessments and governance processes into separate categories (see pre-assessment and decision-making below), in this thesis I have combined a number of IRGC guiding premises to create a combination of these two elements. My intention was to establish a risk governance assessment for livestock policy in the EU.

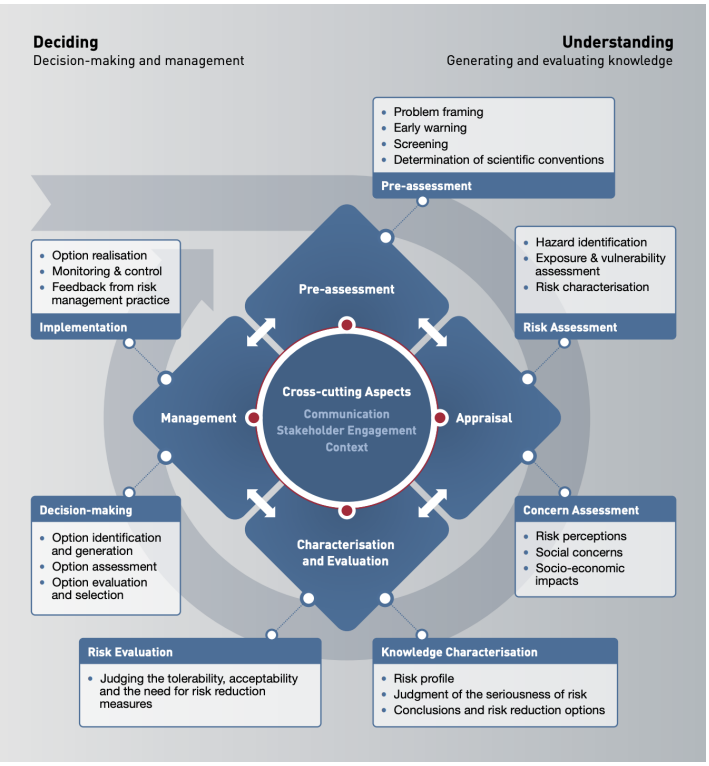


Figure 5: IRGC Risk Assessment Framework[189].

To be applicable to this research, the IRGC stages have been reduced to 4 that encompass risk governance through assessing objectives and priorities according to the characterisation of risk. The categories are as follows: (1) metrics, (2) knowledge characterisation, (3) boundaries and (4) recommendations/solutions. Each category is based on IRGC descriptions of how risk can be defined and how decision-making processes follow. The table below gives an overview of the questions that guide the characterisation of risk. These questions were formulated by myself in order to have a frame of reference to revisit while reviewing the data. This enhanced standardization, replicability and validity of the analysis.

Category	Definition/guiding questions
Metrics	How is the topic defined in how it is measured? What specific metrics are used (e.g. carbon for emissions) Who is using which metrics, and do these differ among stakeholders? Are there differences in metrics across disciplines? Is it possible for the risk to be quantified?
Knowledge	Complexity

[189] Florin, Marie-Valentine, and Marcel Thomas Bürkler. *Introduction to the IRGC risk governance framework*. No. REP_WORK. EPFL, 2017.

characterisation	Uncertainty Ambiguity When is a risk (un)certain? What level of certainty is required to incite action? What level of risk is deemed sufficient to take action? How is the severity of risk characterised? Do solutions appeal to the severity? (if they do, in what ways?)
Boundaries	Scope (what is included in the definition of risk? E.g. what animals are included in an emissions risk assessment?) Over what time horizon are impacts expected to arise? Scale (what is the scale of impact, the sphere of influence)
Recommendations /solutions	What solutions or recommendations are offered to mitigate the risk? Do the approaches differ across stakeholders? Do the approaches diverge across levels of governance?

While there are a limited number of risk assessments for parts of livestock management, a conscious choice was made not to use these. This research could have combined existing risk assessments, for example using the EFSA animal welfare, or the Dutch food safety assessments complemented by others for the remaining SCAR categories (economy, organic, emissions, diversity). But since the guiding premise of this thesis is 'alignment', it was reasoned that using risk assessments using a range of indicators, metrics and assumptions would be antithetical to alignment. Inconsistencies in the characterisation of risk and governance would also make it difficult to compare across sources and types of data. The overall literature and research gap in this area means that definitions, metrics and indicators are consistently lacking, requiring a novel approach to risk governance for livestock that suits the research gap explored by this thesis.

Findings

This section presents an overview of the data collected and analysed in order to establish the extent to which EU policies for livestock are aligned with risk. Using the literature review (which combines risk assessment with EU policies) and member state national strategies, alignment was measured according to five categories outlined in the analytic framework section of this thesis. Broadly speaking, the literature review of European level policies brought to light one clear trend; the consistent exclusion of livestock in food and agriculture policy. Most often, environmental or holistic sustainability plans such as the Green Deal targeted a host of benefits but failed to explicitly make links to livestock and the industry's contribution to human health, the environment and socio-economic development. Pieces of legislation targeted at agriculture in particular often hone in on arable farming and the potential to mitigate environmental or economic damages to this system, drawing vague but clearly plant-focused boundaries around agricultural policies. At times livestock is mentioned, in particular in relation to land use and land use change or in the use of antibiotics. But overall, it is crucial to note that livestock is represented as a footnote in overall EU policies. The only exception to this is in veterinary medicine policies or welfare legislation aimed at reducing pain and suffering in farmed animals.

What is consistent throughout EU level policies is the lack of metrics, definitions and indicators for animal production systems. A 'sustainable livestock sector' remains undefined and unclear, even though myriad policies report recognising the impact the livestock sector has on the environment, economics and overall development. The 'One Health Approach' is used by EU policies as a proxy for a sustainable food system in that it encompasses public, animal and environmental health and establishes their interdependent relationship[190]. At times, this broad framework models an ambition for what the EU food system could look like, and yet the individual policies needed to fulfil this ambition are not yet evident in EU agricultural, food and environmental policies.

On a member state level, the data is more nuanced and inclusive in terms of livestock. This can be attributed to the nature of data collection, as ministries of member states were requested to submit livestock or environmental strategies for analysis. Select member states have comprehensive livestock strategies that target a host of risks in animal production. Even so, the majority of strategies are similar to EU policies in that arable farming takes centre stage. This is especially the case in broader environmental and agricultural strategies, animal production is often a side note or an approach grouped into a list of approaches without much explanation or justification. Across member state livestock strategies there is a lack of coherence, individually they complement one another but across issues co-benefits are limited. Policies are targeted very specifically at antimicrobial resistance or reporting or welfare but not at animal welfare across a number of variables. There is an overarching lack of systems thinking, meaning issues are targeted in siloed approaches rather than holistic, multi-disciplinary improvements.

Across member state strategies metrics, indicators and clear definitions are absent. This applies to general problem statements for the livestock sector, to solutions as well as to goals and targets. Some examples of a lack of clear definitions include statements like "environmentally sound food consumption" without further clarification what this entails. The gap in definitions and clear metrics is especially evident in animal welfare. While there is widespread agreement that welfare is important and generally at a high level in the EU, there are no clear indications as to how welfare is measured in a tangible way. The infamous line by Peter Drucker "You can't manage what you can't measure" comes to mind here.

As with the literature review, this analysis is structured according to the six topics identified as key for the transformation of the livestock sector by the SCAR; greenhouse gas emissions, diversity, economy, consumption, animal health & welfare and organic agriculture. The analysis is visualised by tables with red, green or grey boxes symbolising alignment, lack thereof or inconclusive/a lack of input, respectively. Appendix 3 shows a summary of the analysis conducted in this thesis.

1. GHG emissions

[190] FAO, World Organisation for Animal Health, UNEP, and WHO. "One Health High Level Expert Panel - Annual Report 2021." World Health Organization, 2021.

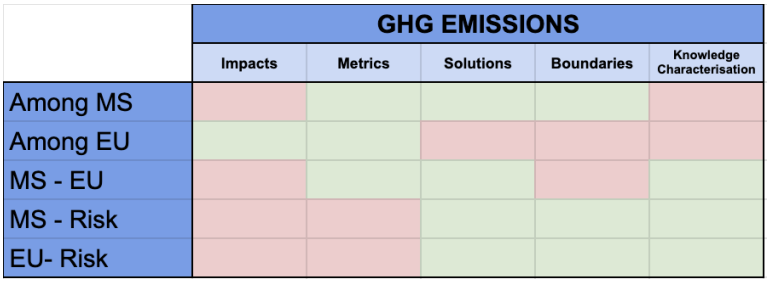


Figure 6: Alignment of policies for GHG emissions, per category and level of comparison.

Among Member States

Among member states three out of five risk categories showed alignment. In terms of impacts, that is the problem definition according to GHG emissions, the framing is inconsistent among member states. While climate change is included consistently across strategies, the impacts of failing to mitigate climate change are unclear and inconsistent. The lack of alignment is assessed by the inconsistency in impacts of climate change across the 20 member states. There is a general consensus that climate change is a risk and requires attention, but the impacts are not explicitly or consistently described. Changing weather conditions are a common consequence, but this is only mentioned by 4 countries out of 20. Other impacts such as changing access to freshwater, heat stress in livestock and the loss of arable land are included individually but are not reiterated across member states. Livestock and its contribution to the problem, as well as impacts on the sector are underrepresented across strategies.

As for metrics, while the emissions from livestock are underrepresented compared to crops and soils, there is a clear trend and repetition of the notion that livestock is a significant contributor towards anthropogenic emissions. Nitrogen and methane are consistently linked to livestock. Overall, there is still a focus on the mitigation and sequestration of carbon emissions over other gases. Many countries have emissions reduction targets, mostly for carbon but also for nitrogen and methane.

Solutions in GHG emissions are aligned across member states. Generally, feed composition, manure management, renewable energy use, and carbon sequestration through land preservation and restoration are consistently used as solutions in mitigating the GHG emissions risk (climate change). These same solutions are brought up by member states repeatedly, therefore there is alignment in this category. Some areas that compromise alignment include disagreements on grazing and grassland feeding. Grazing is outlined by some as a better strategy for digestion, but by others the land use change contribution to emissions and biodiversity loss challenges digestion benefits. There is clear tension between whether grazing animals are seen as positive or not to a system. Some countries frame them as an integral part of ecosystems while others say they take up too much valuable land and conflict with urban expansion.

Trade-offs in extensive grazing arise across member states, with no clear consensus on what is an appropriate solution. This is what the lack of alignment for knowledge characterisation is based on. Broadly speaking, the lack of clarity on the extent to which certain measures can improve conditions. Claims range from specific impacts such as a reduction in nitrogen emissions to broad claims about improving biodiversity and waste streams.

In terms of boundaries, member states are aligned in their characterisation of the species involved in this problem. Linked back to the impacts section, the largest contributors to emissions are ruminants,

this is consistently reiterated by member states. There is a consistent focus on individual member state conditions and their strategies. The need for collaborative effort across member states is not mentioned by any countries.

Among EU policies

While climate change is recognised as a key threat that needs to be dealt with very soon, livestock's contribution specifically is underrepresented. The agriculture sector is described by the CAP as being more vulnerable than other sectors. Focus is largely on arable farming. Mixed on livestock contribution, majority recognise its contribution as significant. Therefore livestock is included as an area that needs to undergo change. Overall this section is aligned as the impacts of climate change are uniformly characterised in a broad but vague way encompassing biodiversity and the economic dependence on nature. The economy and nature are described as intrinsically linked.

For metrics, EU policies typically use percentage contribution or reduction of GHGs by agriculture or livestock. Specific metrics on how exactly to gauge progress for livestock are constantly lacking. CAP metrics are much more targeted and break down what they will measure, but still in percentage contributions. Overall targets for 2030 or 2050 are in percentage reductions of emissions.

Solutions at an EU level are not aligned. Most often, manure management and biogas production are repeated. Grazing is less common, herd management and housing infrastructure even less. There is a clear lack of specific interventions for livestock outside of the CAP, especially in the ETS, Climate Target Plan and ESR. One solution that is mentioned somewhat often is the role the EU can play on an international scale. Essentially a recognition that the EU needs to collaborate with the rest of the world in order to meet emissions reductions targets.

The boundaries for GHG emissions are not aligned. Descriptions are very inconsistent on what is included. Land use and land use change are used to encompass agricultural emissions, and rarely are accompanied by a small note on the contribution of livestock to these emissions. Livestock is often grouped into the category 'agriculture' without its own elaboration or nuance on emissions from livestock as separate from arable farming. Gases used to describe the problem are relatively consistent; nitrogen (ammonia), methane. There is still a consistent focus on carbon. Ultimately not aligned due to the way the gases and classification of contributions to emissions neglect livestock.

In terms of knowledge characterisation, there is limited input. In addition, there are conflicting statements of certainty on the emissions reduction potential of certain solutions. The tradeoffs in grazing are noted once again.

Member State - EU policies

The impacts of GHG emissions are not aligned due to the focus for both as largely on arable farming, although EU policies single out livestock as a significant part as well, therefore suggest that the livestock sector needs to undergo change in order to meet climate goals. Although both represent climate change as a significant issue, the specific impacts and repercussions of inaction are not clear on an EU level, whilst some member states have described individual issues such as local drought, heat stress in animals and loss of land.

In terms of metrics, EU and MS documents focus mainly on percentage reductions of emissions. Emissions targets diverge, but the metrics used are percentage reductions, so in this they are aligned. There is still an overwhelming carbon focus, as well as an arable farming focus. Both EU and MS policies include emissions reductions targets, not targeted at livestock but instead broadly on emissions.

Solutions are aligned across EU and MS policies. Manure management and biogas production are consistently included as valuable emissions reduction strategies. That said, MSs have more specific and targeted interventions depending on national contexts, compared to the EU interventions. EU policies offer more broad approaches that are less descriptive and act more as headline solutions such as 'sustainable housing practices' without further elaboration on what this entails. EU policy in general proposes much more of a framework type host of solutions and then sets out the expectation that MSs will implement appropriate solutions according to their own contexts. Other solutions mentioned include housing infrastructure, herd management and animal breeding for emissions reduction.

The boundaries for this category are not aligned between EU and MS policies. The EU focus is more broadly on emissions, does recognise ruminants but more often makes broader claims about the 'agriculture' industry than specifically livestock. Have similar timeline goals, for 2030 and 2050. Both exclude poultry and pigs and focus mostly on ruminants. The EU makes explicit that cooperation is needed to reach climate goals. MS do not relate their goals to the int. Community or other member states.

Finally, there is alignment around knowledge characterisation of this risk. They make similar conflicting statements about trade-offs and the potential to mitigate emissions. Progress indicators are consistently absent, which makes it unclear whether these strategies will really contribute to the targets set for 2030/2050.

2. Diversity

	DIVERSITY				
	Impacts	Metrics	Solutions	Boundaries	Knowledge Characterisation
Among MS					
Among EU					
MS - EU					
MS - Risk					
EU- Risk					

Figure 7: Alignment of policies for diversity, per category and level of comparison.

Among Member States

Overall it is clear that MSs are aligned on that biodiversity is in decline due to agriculture, and that it is negative. But the impacts of biodiversity loss more tangibly are inconsistent. Some countries claim biodiversity has an impact on climate change (such as Norway and Finland), others separate the two (France), others make broader statements about negative impacts on liveability and productivity (The Netherlands). This means that the impact is unclear and unfocused. Having said this, it is clear that MSs are in agreement that biodiversity loss is taking place and that it is a problem that needs to be addressed. The link to livestock is also consistently absent.

Metrics for diversity are inconsistent and thus not aligned across member states. Some name pollinators, others habitats, others farmed animals such as cows. Germany is the only MS that mentions the Habitats directive and tangible metrics for biodiversity such as the conservation status of species. There is overall a very inconsistent use of measuring progress on indicators. Almost no member states reflect on the tangible state of the decline in biodiversity. They just say it is at a critical state or it is in decline. Here the lack of definitions, indicators and metrics is evident.

The solutions section is a continuation of the impacts in that there is agreement that biodiversity needs to be improved but it is unclear how exactly. There is a large range of approaches and none of them are particularly clear. Crop rotations and diversity in cropping is mentioned in a limited way. Improving on farm animal species diversity is not included. Extensive grazing is hailed as positive by some, and criticised for ineffective and inefficient land use by others. Some say organic farming is also a way to improve biodiversity while others use it as a broad proxy for sustainable farming. The mention of Natura 2000 areas as a proxy for biodiversity solutions is frequent, yet there is no explanation as to how these areas promote biodiversity outside of preservation and conservation of species and habitats. Again, the direct and explicit link to livestock is lacking from all solutions.

The boundaries of diversity as a category are not aligned across member states. Overall it is difficult to establish trends across member states, as they include very different definitions of biodiversity. Typically animals included are birds, pollinators, cattle, wild animals, habitats. Estonia and Italy are the only MSs who mention local and indigenous breeds of farmed animals. Outside of this there is very sparse to no mention of domesticated animal diversity. Spheres of influence are fairly consistent in that strategies only account for diversity within national borders. There is no mention of European scale biodiversity or that wildlife crosses borders. Time horizons for framing the problem or solutions are also consistently excluded.

Finally, in terms of knowledge characterisation member states' strategies are aligned. They claim that biodiversity is an issue in the impact statement and description. Biodiversity loss is negative. There seems to be no accounts of uncertainty around this. Action needs to take place, seems to be concrete agreement on this. As in each previous category, there is a very limited inclusion of livestock.

Among EU policies

Among EU policies impacts are aligned as they each lack insight and focus towards domesticated animals. That is, they are aligned in their neglect of livestock production and the potential for livestock to contribute to mitigating biodiversity loss. The repercussions of biodiversity loss are unanimously neglected, meaning these are not addressed in any strategies. Only the Farm to Fork Strategy mentions the potential for animal biodiversity to improve resilience and potentially prevent the spreading of disease in the future. There is an implied link between biodiversity and climate change in that there is some consensus that ruminants contribute to climate change and that climate change and biodiversity go hand in hand. All in all, the explicit link between livestock and biodiversity is absent.

In terms of metrics, across EU policies similar indicators are used. Most often the indicators focus on land use such as 'area under conservation' or protection. All indicators are built around conservation and preservation, either of habitats or species. In species butterflies and birds are measured, as well as some wild animals listed in the Habitats Directive. Livestock and domesticated species breed tracking is only included in the Animal Breeding Regulation and is absent from the Biodiversity, Farm to Fork Strategy, EU Habitats Directive, the Nagoya Protocol, the CAP and Natura 2000 legislation.

Solutions for diversity, similar to the metrics, consist almost entirely of conservation and preservation efforts which are consistent across EU policies. Solutions are relatively vague in their aim to protect and conserve habitats and species. There are very few details on what effective conservation entails other than labelling an area as 'protected', for example under the Natura 2000 regulation. These areas aim to create a safe breeding ground for protected species. There are no set 'best-practices' for Natura 2000 management, the regulation states that efforts "...rest on scientific knowledge and should be defined on a case-by-case basis, which means that the ecological requirements can vary from one species to another within a site but also for the same species from one site to another."[191]. Finally, the overall lack of interventions for promoting diversity in livestock applies here. The only policy promoting diversity is in the Animal Breeding Regulation in which in situ and ex situ conservation are mentioned as ways to conserve genetic resources.

The boundaries for biodiversity are not aligned among EU policies. First and foremost there are very few legally binding requirements in mitigating biodiversity loss. The Biodiversity Strategy recognises this explicitly in saying "...there is no requirement for Member States to have biodiversity restoration plans. There are not always clear or binding targets and timelines and no definition or criteria on restoration or on the sustainable use of ecosystems. There is also no requirement to comprehensively map, monitor or assess ecosystem services, health or restoration efforts."[192]. In addition, the descriptions of biodiversity diverge across policies. The impacts, species included and purposes of preventing biodiversity loss are inconsistent, at times targeting nature on farmland, at others wild species. The conservation of habitats is a fairly consistent inclusion in strategies to improve biodiversity.

Knowledge characterisation in relation to biodiversity is not aligned among EU policies. There are inconsistent descriptions of the severity of the impacts of biodiversity loss. The Biodiversity Strategy is clear in saying "...nature is in crisis", yet the Farm to Fork Strategy lists biodiversity as part of a general list of concerns, not as a central threat[193][194]. The Habitats Directive is very clear that extinction of certain species is a grave threat, but does not detail what exactly what the feedback loops are that could follow extinction. As the metrics and boundaries for diversity do not align due to the range in indicators and understandings of what biodiversity is, the characterisation of knowledge also diverges.

Member State - EU policies

Among EU policies, impacts are aligned in their consistent neglect of livestock, that is the impact on and contribution of livestock to biodiversity loss. Note here that land use or the expansion of agriculture outside of the EU have been excluded from this analysis. Both the EU and member states recognise that biodiversity loss is a significant threat but do not clearly characterise why and how. The only consistent link that is made is between biodiversity and climate change, in that the combination of these can build resilience in a system.

[191] European Commission. "Commission note on establishing conservation measures for Natura 2000 sites," 2013. https://ec.europa.eu/environment/nature/natura2000/management/docs/commission_note/comNote%20conservation%20measures_EN.pdf

[192] European Commission. "Biodiversity Strategy." European Union, 2020. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

[193] European Commission. "Biodiversity Strategy." European Union, 2020. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

[194] European Union. "The Farm to Fork Strategy," Slide show 2022. https://food.ec.europa.eu/system/files/2022-04/f2f_international_lac_wkshp_20220322_pres-01.pdf.

In metrics for biodiversity, as mentioned previously member states have consistently failed to include tangible indicators and metrics. EU policies in this regard exhibit some metrics such as 'habitats protected' or 'species protected'. Overall both EU and member state policies entirely exclude livestock diversity indicators.

Solutions to tackle biodiversity loss are not aligned. While protection of Natura 2000 areas and High Value Nature areas is common, other solutions are not consistent between EU and member state strategies. On a member state level, interventions are more nuanced for example suggesting crop rotations and legume planting for diversity. On an EU level, interventions are more broad such as suggesting the expansion of Natura 2000 areas as well as increasing monitoring and reporting of species (mostly wild).

The boundaries are not aligned in this category. Both levels of policy are consistently lacking a livestock perspective. They are also consistently vague and divergent in their description of what is to be included in, and understood by 'biodiversity'. Member states have a clearer overview of specific species/types that should be accounted for such as pollinators, cattle, birds, wild animals and habitats. Member states do not include time horizons associated with biodiversity targets, while the EU sets 2030 targets in the Biodiversity Strategy.

Finally, knowledge characterization is not aligned among MS and EU policies. The CAP recognises an inconsistency in data collection for diversity. It claims the measurement of habitats and species has been sparse and intermittent, which compromises insights gained from the data. Due to the lack of clear definitions and indicators, across policies there is no consensus on what the severity of biodiversity loss is. The metrics and indicators used are not comparable across policy levels. Overall there is an extremely limited inclusion of livestock.

3. Economy

	ECONOMY				
	Impacts	Metrics	Solutions	Boundaries	Knowledge Characterisation
Among MS					
Among EU					
MS - EU					
MS - Risk					
EU- Risk					

Figure 8: Alignment of policies for economy, per category and level of comparison.

Among Member States

There is alignment among member states in terms of the economy problem statement and impacts. There is a general consensus that the agriculture industry is a significant contributor to both rural development and national economies. There is also a consensus that there needs to be a transition of some sort. The description of why there needs to be one ranges from broad environmental impacts to concerns over farmer incomes. The food industry is described as having a wide reach and therefore its impacts are widespread. An economic and system-wide transition is needed and requires significant investment. The repercussions of underinvesting or failing to invest at all are unclear. Succession is

under threat. Overall, livestock considerations such as specific notes on livestock farmers are neglected. Lastly, there is a common recognition of the member state dependence on international trade flows and globalised supply chains for economic gains. The threat of a supply chain disruption is therefore recognised by MSs and identified as a major economic concern moving forward.

The metrics for economics are aligned among member states. There is a broad consensus here that government spending is a significant contributor to the transition. There is a clear indication that the government will need to make substantial investments in order to facilitate a transition to a more 'sustainable' food system. In addition, the CAP and its financial instruments are mentioned often in enabling the agriculture/food industry as a whole. Some countries note their dependence on the CAP. There is consistent mention of currency as a metric, specific quantities listed that are needed to bridge x gaps in for example animal welfare or infrastructure improvements. At the same time, there are also broad general statements that 'investment' is needed without quantification. There is a consistent lack of alternative streams of funding such as private or EU contributions outside the CAP as an additional metric.

A broad range of solutions is offered that are not Particularly consistent across MSs. The following solutions come up sparsely and inconsistently: education & training, research & innovation, true cost accounting, trade mechanisms, self-sufficiency (to mitigate dependence on globalised supply chains), and national subsidies. All these solutions require funding and investment. The trend here is that there is a lack of consistent, clear solutions to the funding gap needed to facilitate a transition to a more sustainable food system. As is customary, there are no targeted solutions to bridge a gap in livestock farming systems.

The boundaries for this category are undefined/inconclusive. There are very few time horizons, scale, scope and clarity associated with financial mechanisms needed to target a transition. Finally, in terms of knowledge characterisation member states are not aligned. Some member states very clearly assign portions of funding to innovation and research or subsidies, others just broadly say it will be costly to transition. There is very little indication of certainty for what it will cost to facilitate a transition to a sustainable food system. Furthermore, the extent to which solutions can offer cost abatement is also very limited. Germany is the only member state that reflects on how costs can be saved by implementing short term solutions. It does this in framing improvements in animal husbandry as a way to reduce costs in the long term, specifically by building resilience in animals so that they are ill less often. Even in this example, the German strategy claims there is no way to quantify the effects of such interventions.

Among EU policies

Impacts among EU policies are aligned. Overall the need for investment into a transition of sorts is clear. There is a widespread call for investment into myriad solutions. The main mechanism for agriculture in the union is a financial compensation instrument (CAP). Inputs for the economy category include the Farm to Fork Strategy, the Biodiversity Strategy and the CAP, with the latter as the main focus. There is also a consistent exclusion of what actual impacts will take place if investment does not occur.

Metrics for compensation are consistent, as the CAP metrics are the main mode of financial compensation for farming activities in the EU. Overall these indicators, listed in the CMEF context

indicators[195], range from labour productivity, (self) employment rates, incomes and structure of the economy. Many of the solutions listed by EU policies are reinforced by the CAP. Measures under both pillar 1 and 2 of the CAP encourage environmental interventions, thus are consistent with the calls for investment into solutions mentioned in the impacts section. Metrics explicitly for livestock in the CAP include; number of animals, quantities eligible (number of hectares/number of animals), number of beneficiaries of school milk scheme.

Solutions for bridging the financial transition to a more sustainable agricultural sector are aligned. Solutions as represented in the CAP are compensations for 'good behaviour' in agricultural practices. These are defined by the EC and then enacted by member states according to their national contexts. The Farm to Fork and Biodiversity Strategies reinforce CAP compensation as effective in financing sustainable practices for agriculture. All in all, EU policies consistently neglect targeted financial instruments to promote sustainable livestock farming practices.

The boundaries of the framing of economics in relation to livestock in EU policy are aligned. This is purely based on CAP pillars which are reinforced and repeated by the Farm to Fork and Biodiversity Strategies. Again, a livestock focus is consistently lacking. Finally, knowledge characterisation is aligned due to the absence of any criticism or questioning of the financial structure of the CAP.

Member State – EU policies

Impacts among member states and EU policies are aligned. Both levels of policy frame economic priorities as a 'package deal' of sorts. That is, to invest in biodiversity and emissions reduction would have run on effects for employment and income in the EU. There is a repetition of the notion that the economy cannot be separated from nature, for example the Biodiversity Strategy claims "Experience has shown that what is good for nature is also good for the economy. It is no longer a choice between nature on the one hand and the economy on the other, but an imperative of making the two work in partnership for the benefit of society as a whole.[196]". There is also repetition that a transition cannot sacrifice either nature or the economy. Although at times there are conflicting statements about this, some statements prioritise one over the other.

The metrics used to measure investment and financial contributions to an economic transition are aligned among MS and EU policies. Both policy types make use of metrics such as employment rates, investment needs, GDP and the contribution of agriculture to national and union level economic prosperity. It is overall clear that livestock's contribution to this is not made explicit. It is important to note that the overall definition for 'economy' is unclear. In part this is because the EU and MS policies do not define exactly what this entails.

In terms of solutions MS and EU approaches align with one another. This conclusion is predominantly based on the attention paid to investment in research and innovation, as well as on education and training. True cost accounting is also mentioned as a solution by both sources. While on a member state level the solutions differ, each of these elements is covered by overarching EU policies such as the F2F and Biodiversity Strategy. Solutions include; national subsidy programs, education and training, trade

[195] European Commission. "CAP Context Indicators - 2019 Update." 2022. https://agriculture.ec.europa.eu/system/files/2022-07/cap-context-indicators-table_2019_en_0_0.pdf

[196] European Commission. "Biodiversity Strategy." European Union, 2020. https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en

policies, true cost accounting, research and innovation, as well as self-sufficiency (in general less dependence on globalised supply chains).

The boundaries component for the economy category is inconclusive due to a lack of input. The overall lack of definitions, scope, time horizons and scale of policy interventions that relate to the European economy make it impossible to conclude whether there is alignment. Finally, the knowledge characterisation for this section is not aligned among member state and EU policies. There is very little reflection on uncertainty overall. Some member states say the transition cannot be quantified, while others claim set quantities are needed for for example research and development investments. On an EU level, the CAP mechanisms are not questioned as the metrics are set.

4. Consumption

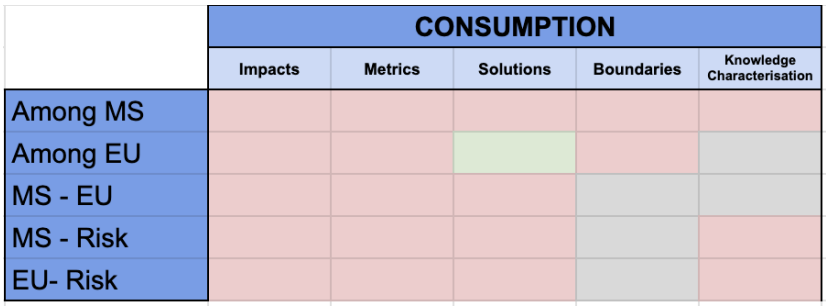


Figure 10: Alignment of policies for consumption, per category and level of comparison.

Among Member States

For consumption, it is clear that member states are focused on consumer health, well-being and preferences. But explicitly in relation to animal products for their nutritional quality there is very little input. Overall definitions and characterisation of what it means for a consumer to be consuming a 'healthy diet' is unclear, and the repercussions of unhealthy consumption patterns are missing. Some member states recognise non communicable diseases as an effect, but this is infrequent. Consumer preferences are considered very important and are addressed through labelling and transparency efforts. Overall there is no clear consensus on what the risk of livestock production is to consumers.

The metrics for this category are also not aligned. The only metric that is repeated is demand and consumption through purchasing behaviour. This is not in line with the impact/problem definition of consumer health and well-being. In particular, the link to animal products is neglected. Consumption and purchasing patterns are generally broad on the label and nature (organic, welfare, environmentally friendly) not on the product itself (e.g. vegetables, cereals or ASF). There are no real mentions of metrics of health such as obesity (with the exception of the UK), cardiovascular disease or osteoporosis.

Solutions for the consumption category overall are not aligned. Measures to improve consumer health and well-being are inconsistent, especially when it comes to ASF. In addition, there is a lack of measures suggested to improve human health through dietary patterns. There are some broad ambitions to reduce hunger and improve nutrition, but tangible ways in which to achieve these are absent. At times there are calls to shift to a more sustainable dietary pattern or food system but this is not common. More focus on overall environmental impact of food in general but not on specifics. One solution that is common is labelling and transparency for the sake of biosecurity. This aims to target zoonoses and foodborne diseases instead of nutrition.

The boundaries for this category are not aligned across member states. While human health seems to be central to member state strategies and is often described as a priority, definitions to make clear what exactly this entails are lacking. There are some brief statements about trends in meat consumption, but these vary according to member states. In some, consumption of ASF is increasing, in others national demand is decreasing but international demand stimulates production for export. It is unclear from these strategies which animal products are of importance to human health.

Finally, in terms of knowledge characterisation member states are not aligned. There are no consistent descriptions of what a healthy diet entails and what the role of animal products is in this. Some member states describe ASF as crucial to national diets while others promote more plant based products and diversified protein sources (France), others still claim local diets are the most beneficial in terms of health and environmental outcomes (Finland).

Among EU policies

Impacts among EU policies are not aligned as they all point in different directions. The CAP overall is lacking a health and nutrition stance. F2F is the only policy that really hones in on diet and non-communicable diseases, it also has the most 'holistic' approach to the problem - the 'One Health Approach'. The EU Cancer Plan is exclusively on cancer and includes diet as a part of the strategy. While the severity is clear and action is needed it is not particularly oriented towards animal products, although there is a note "and in line with the shift to a more plant-based diet, with less red and processed meat and other foods linked to cancer risks and more fruit and vegetables.". The EU Cancer plan does have a follow up on an F2F measure: change school schemes, so there is some alignment between these two. The General Food Law is most concerned with food safety and neglects nutrition. While transparency, labelling, marketing and such are mentioned, the inclusion of the consumption of animal products and such is lacking in this policy. The General Food Law is mostly concerned with the production, rather than consumption side of food. The EU Quality Schemes regulation centres around labelling, marketing and consumer trust. Ultimately, a livestock and animal product focus is not included in any of these policies.

Metrics are not aligned among EU policies. Each policy is focused on different metrics to characterise the problem. This is a continuation of the impacts section, whereby each policy focuses on a different element of food policy. The CAP measures the use of antibiotics, and consumer price evolution of food products. The F2F measures nutritional profiles, deaths due to diets, consumption patterns compared to nutritional guidelines. The EU Cancer Plan measures the maximum level of contaminants in food as well as disease risk factors in humans. That is, factors that make individuals more prone to cancer such as genetics. The General Food Law is vague in what it measures, while its focus is on food/feed safety there is no mention of pathogens or acceptable level of contaminants. For the Quality Schemes Regulation, the quantity of geographical indicators for food products are listed as a metric. All in all, metrics diverge across policies.

The solutions for consumption in the interest of consumer health and well-being are aligned. Policies accounted for all have a very limited inclusion of livestock and animals in general. There are some brief notes on animals in terms of feed or red/processed meat consumption, but in general ASF are neglected and framed as more of a side note than a central strategy by which to improve consumer health. Throughout these policies, the most common solution is increasing transparency and labelling to build consumer trust in food products. There is frequent mention of increased consumption of 'healthy foods',

but very little explanation of what exactly this entails. Overall, the promotion of fruits and vegetables is popular.

The boundaries for consumption across EU policies do not align. Since impacts diverge, metrics diverge, the boundaries are also divergent. There are inconsistent problem definitions and a very limited application to animals and animal products. It is unclear on which animals/products are being targeted as well. Feed considerations are not specified for which animals or purposes exactly.

For knowledge characterisation there is a lack of input from EU policies. Overall there are unclear delineations of what characterises certainty. The origins of claims about health and consumption are unnamed and unfocused. There is no call for an extension of research into human health and the impact of diets or animal products.

Member State - EU policies

Impacts among member states and EU policies are not aligned. While EU and MS policies diverge in their framing of healthy diets, there is some consistency in the mention of a need for an increase in plant based foods. What stands out in both levels of policy is that consumer preferences are considered a priority in establishing food quality standards. What is unclear is what the repercussions might be of failing to respond to consumer demands, for example insufficient income for retailers or producers. Consumer health is central across EU and MS policies, yet it is unclear what exactly health encompasses, as in whether this pertains to disease and zoonoses or to nutrition. At times impacts such as obesity, cancer, diabetes are mentioned and at others foodborne diseases are made central.

The metrics used to measure consumer health are not aligned across EU and MS policies. The Farm to Fork Strategy mentions average intakes of energy, red meat, sugars, salt and fats, deaths due to dietary habits, as well as average consumption patterns compared to nutritional guidelines. On the other hand, the EU Cancer Plan lists maximum levels of contaminants in food as a metric for consumer health. Further EU level policies measure elements like the number of geographical indicators (e.g. DOP). Member states on the other hand only somewhat consistently measure the demand and consumption through purchasing behaviour. In addition, the focus lies more on the label of the product (e.g. organic, welfare standards) than the product itself (cereals, vegetables or ASF). As in most other categories, the failure to make links between animal products and health is consistent.

Solutions for the consumption category are not consistent among EU and MS policies. The taxing of certain foods is uncommon among member states, but is suggested as a viable solution on an EU level. There is no specific mention in either of animal products, only the intent to decrease VAT on fruits and vegetables while increasing VAT on high sugar foods such as soda. Ultimately, there is no clear consensus on how diets should be improved. On a member state level, dietary recommendations are suggested while the EU policies neglect this option. In addition, reducing the marketing of ‘unhealthy’ foods is an EU solution but is not recognised by member states. The only solution that is consistent among the two is increased and more nuanced labelling of foodstuffs, following the aim of improving transparency towards consumers.

The conclusion for both the boundaries and knowledge characterisation among policies cannot be established. Since impacts, metrics and solutions diverge there is little common ground between EU and MS policy on the contribution of ASF consumption to human health. The distribution of responsibility is also inconsistent, reporting and monitoring is said by EU policies to be the

responsibility of member states and yet these give no clear indication that they are meeting this expectation.

5. Animal Health and Welfare

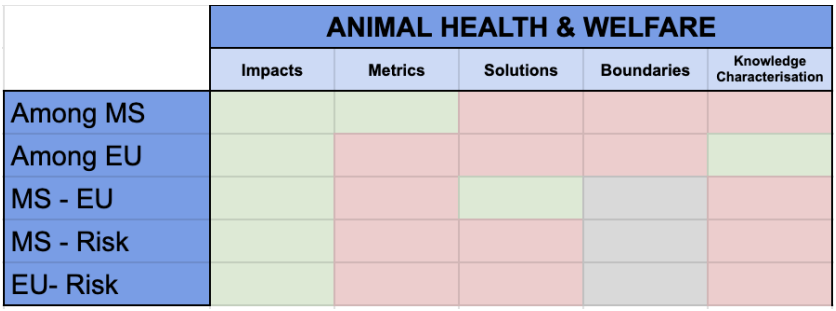


Figure 11: Alignment of policies for animal health & welfare, per category and level of comparison.

Among Member States

Antimicrobial resistance and disease outbreak is central, although the consequences are not described in detail. Many countries say that antimicrobial resistance is a threat and propose a host of solutions and mechanisms through which to reduce said risk. But they do not describe what will happen if antimicrobial resistance happens. Some say public health, and overall impact on public/human health which leads to the assumption that the ultimate concern is food safety and public health through the mitigation of antimicrobial resistance. Many countries include some recognition of the importance of animal welfare, but antimicrobials are consistently linked to animal production and are described as being critically important without including exactly in what ways.

The metrics used overall are aligned with the impacts described above. Member states are aligned in their overall ambitions to reduce the use of antibiotics and thus need to measure the sales and use. Ambitions to reduce antimicrobials in animal production are popular, although specific reductions targets are sparse. There is a general agreement that metrics for animal health and welfare still need to be developed outside exclusively antimicrobials. Ultimately there is a gap in metrics identified across member states.

Solutions for this category are not aligned. Broadly speaking, the solutions are aimed at animal health and welfare, but not specifically at antimicrobial resistance. Interventions are distributed across parameters for health and welfare, targeting the general reduction of pain and suffering. Other than monitoring the use and sale of antimicrobials, there are no alternative avenues to prevent or reduce use of antibiotics, such as the development of other curative medicines. The range of solutions across member states includes; labelling and certification of welfare standards, the development of legally binding welfare standards, investment in innovation and research for welfare, infrastructural improvements for welfare (e.g. to allow ‘natural behaviour’ of farmed animals), avoidance of ‘non-curative interventions’ on animals (e.g. tail docking, beak trimming, preventative use of antibiotics).

The boundaries for animal health and welfare are not aligned. The animals included in antimicrobial resistance are not outlined consistently, although pigs under intensive production are mentioned by a few member states. Time horizons within which antimicrobial resistance proves a threat are not included. Some member states mention the ‘One Health Approach’ as a framework that guides their vision for animal and public health. Yet, the application of this framework is inconsistent. Some

member states build their strategies around this while others mention it briefly without integrating it into their own strategies.

Lastly, the knowledge characterisation is not aligned for animal health and welfare. Overall, the trade-offs and co-benefits of certain solutions are inconsistently framed. For example, changes in farm infrastructure that create more open air stalls may improve animal welfare but produce more ammonia emissions. There is no clear or consistent indication which interventions will improve animal health and welfare. There are no measures or statements of certainty either. The severity of risk (antimicrobial resistance) is unquantified and unclear.

Among EU policies

Impacts across EU policies are aligned. There is a clear trend that frames biosecurity and food safety as central to food policy through the identification of AMR and zoonotic/foodborne diseases as key threats. There is a consistent focus of the impacts of biosecurity on human health in terms of disease and contamination. Health care costs are named as a consequence of failing to mitigate these risks. All in all, although animal health is the main focus, the threat is consistently framed as one facing public health and consumers. In relation to animal welfare, EU policy mainly targets harm reduction in that unnecessary pain in farmed animals should be reduced where possible.

Generally the metrics used to characterise animal health and welfare are inconsistent across EU policies. Aside from efforts to monitor and report animal production standards such as location of slaughter or the use of medicines, metrics are unclear and undefined. While the importance of reporting and monitoring to ensure transparency throughout the supply chain is repeated, other metrics diverge. The CAP measures deaths due to antimicrobial resistance per year, economic burden in euros, sales of antimicrobials (mg/PCU). The Farm to Fork mentions human deaths due to antimicrobial resistance as well as healthcare costs resulting from resistance/foodborne illnesses without quantifying this. The Animal Health Law includes specific criteria for disease severity and species risk factors for disease. In terms of welfare, a large range of things are included such as lighting, temperature in stables, space allocated per animal, overall transport conditions and pain mitigation used during slaughter.

Solutions across EU policies are not aligned with one another. There are very few interventions overall that directly target the aim to reduce antimicrobials such as alternative medicinal treatment options. The majority of policies stimulate monitoring and the gathering/sharing of information about veterinary medicines. The Animal Health Law introduces the categorisation and prioritisation of diseases that may require interventions in order to prevent damages, suggests the development of surveillance design for diseases in farmed animals, as well as clear criteria for vaccination against common diseases. The Framework for Veterinary Medicinal Products Regulation calls for a centralised authorisation procedure for veterinary medicines, as well as harmonised standards in the EU for such medicines. The F2F Strategy outlines the need for international cooperation on the global trade of animal products in the interest of mitigating disease outbreaks. Ultimately, solutions deviate and aside from the call for more reporting and monitoring there are few consistent strategies.

The boundaries used to characterise animal health and welfare are not consistent across EU policies. The species and products included in these rules are often unspecified. For example, the Animal Health Law includes "...kept and wild animals, germinal products, products of animal origin, animal by-products and derived products, facilities, means of transport, equipment and all other paths of infection

and material involved or potentially involved in the spread of transmissible animal diseases.[197]". At times, the link between antimicrobial resistance and animal production systems is not made explicit. Time horizons are absent, that is, goals and targets are not clear outside of the F2F goal of reducing the sale of antimicrobials by 50% by 2030.

Knowledge characterisation is aligned on the basis of the research and knowledge gaps identified in myriad EU policies. The CAP, the Framework for Veterinary Medicinal Products Regulation, Animal Health Law as well as the EU One Health Action Plan against Antimicrobial Resistance recognise the lack of research and concrete knowledge on antimicrobial resistance. Each calls for an expansion of research and investment into R&D. Several policies also call for flexibility in legislation around antimicrobial resistance in order to facilitate changes that might need to be made in lieu of new research.

Member State - EU policies

Overall impacts of animal health and welfare are aligned across MS and EU policies. There is a consistent lack of clear characterisation of the repercussions of failing to mitigate antimicrobial resistance or foodborne illnesses. While the public health and biosecurity element is consistent, the consequences of inaction are not made clear. The only recurring premise is that mounting healthcare costs are a threat for the future.

In terms of metrics there is no alignment between EU and MS policies. Only the recognition that current applications of antimicrobials are in excess is consistent. The CAP has limited metrics such as deaths due to antimicrobial resistance per year, economic burden in euros, sales of antimicrobials (mg/PCU) but across other EU policies these diverge. On a member state level metrics are consistently lacking. There is also a misalignment with the threat of antimicrobial resistance, with no metrics to characterise the severity of the problem it is practically impossible to gauge progress.

Solutions are aligned among EU and MS policies. Both focus mostly on labelling, reporting and transparency rather than other tangible solutions to reduce the use/sales of antimicrobials. The boundaries for this category cannot be defined. There is a lack of input across policies based on the absence of time horizons, scope and sphere of influence. Finally, the knowledge characterisation for animal health and welfare is not aligned. EU and MS policies do not equally recognise the lack of research and knowledge/data gaps for antimicrobial resistance. The EU places much more emphasis on this while member states generally fail to acknowledge it. The trade-offs and co-benefits of improving animal health and welfare for example by environmental benefits expressed in emissions reduction are inconsistent.

6. Organic

[197] European Commission. "About the Animal Health Law." Accessed June 28, 2023. https://food.ec.europa.eu/animals/animal-health/animal-health-law_en.

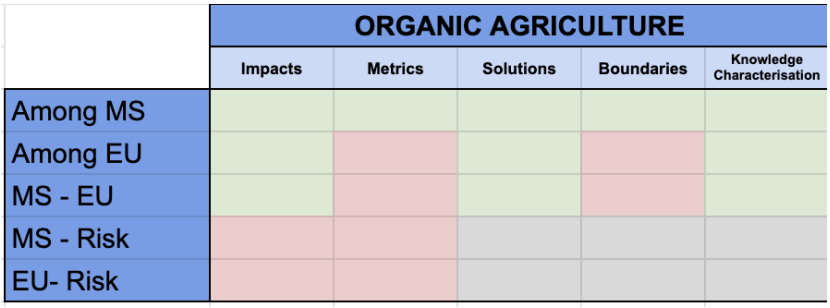


Figure 12: Alignment of policies for organic agriculture, per category and level of comparison.

Among Member States

Across the analysed strategies submitted by member states, organic agriculture is framed as a proxy for sustainable farming. Across member states organic is seen as a positive intervention of which the benefits are widespread. The benefits named include; air quality, water quality, emissions reduction, biodiversity, resilience, improved animal welfare. The specific impacts of implementing organic production are not clear, meaning the nuances of the benefits listed above are not described. But, overall organic production is hailed as a positive mode of farming for the future. The application of organic legislation in relation to livestock is very limited across member state strategies.

The metrics for organic are aligned. Member states describe organic agriculture according to the criteria set by the Commission, meaning they describe a lack of synthetic inputs, antibiotics and more space allocated per animal. In line with this, member states are aligned in their approach to expanding organic production. Many MSs have their own organic action plans in which they outline ambitions to expand the area under organic production. In terms of boundaries, while livestock is explicitly mentioned more than in other categories it is still limited. Organic agriculture is consistently described as a holistic farming system, and mostly targets arable farming.

Finally, the label organic is typically promoted and described in a positive way. Denmark questions the label in that it may be associated with trade-offs due to extensive grazing for welfare and emissions that may come with land use change. Overall, the outcomes of organic are characterised as very positive, with the exception of Denmark raising some concerns over trade-offs.

Among EU policies

Among EU policies, the impacts of implementing organic agriculture are aligned. Organic is consistently described as a 'sustainable farming system' that can offer a host of benefits such as improved biodiversity, fair incomes for farmers, high quality products, satisfying consumer expectations as well as overall environmental benefits. Organic is consistently described as a viable option for the future of sustainable food production in the EU.

The metrics used for organic among EU policies are aligned. The CAP exclusively measures hectares under organic production. The F2F and Biodiversity strategies also measure land area under organic production. The Organic Action Plan also measures land dedicated to organic as well as the public awareness of the organic logo on foodstuffs. Finally, Regulation 2018/848 on Organic Production measures the organic nitrogen linked to total animal stocking density. The area under organic production is the most consistent measure, although this is not a direct measure of livestock under organic the way

livestock heads as a metric would be. Overall there is a lack of metrics specifically for organic animal production.

The solutions for organic across EU policies are aligned. Consistent solutions are expanding the area under organic production, this is reiterated in the Organic Action Plan which calls for CAP strategic plans to include national expansion plans for organic production. Other solutions include promoting education on organic production practices, public procurement of organic foodstuffs and finally promotion campaigns to stimulate public awareness of organic products. Again, the livestock focus is lacking from EU policies, with the exception of Regulation 2018/848 which calls for considerations for animals such as selecting breeds for genetic diversity, treatment for sickness to be limited to "...re-establishing the well-being of the animal", as well as reducing unnecessary pain and suffering[198].

The boundaries for organic are not aligned for their scattered approach to livestock. That is, the species and practices included in descriptions of organic systems in relation to livestock differ among policies. Organic livestock is not addressed directly in the CAP, F2F or Biodiversity Strategy. In Regulation 2018/848 livestock is clearly defined as follows; "'livestock production' means the production of domestic or domesticated terrestrial animals, including insects;"[199]. Furthermore, the regulation defines clearly what exceptions there are to organic rules such as the application of medicines, the integration of non-organic animals into an organic herd or the conditions under which feed is considered fit for organic livestock. The Organic Action Plan only describes livestock production in relation to animal nutrition and welfare.

In terms of knowledge characterisation, EU policies assessed as being aligned. In general, there is no questioning of the organic label or regulation in terms of impacts or effectivity. Descriptions are consistently positive about the range of benefits mentioned in the impacts section of this category.

Member State - EU policies

Impacts across EU and MS policies are aligned. This can be attributed to the consistently positive framing of organic as a holistic, sustainable farming system fit for the future of the EU. Benefits described in both EU and MS policies range from environmental to social to economic outcomes.

In terms of metrics, there is no alignment among policies. On an EU level, metrics are focused on land area under organic whereas member states quite often mention livestock heads or percentages under organic in addition to land area. The member state consistency on addressing livestock compared to EU framing of animals is the main reason for the lack of alignment in this section.

For solutions, there is alignment among EU and MS policies. Almost all interventions are targeted at increasing the land area under organic. This is consistent across policies and levels of governance. The boundaries for organic are not aligned. There is sparse and inconsistent explicit inclusion of livestock and the species described as livestock among member states and EU policies. Finally, knowledge characterisation is aligned due to the almost unanimous support for organic legislation and expansion

[198] European Parliament and the Council. "Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007," 2007. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02018R0848-20220101

[199] European Parliament and the Council. "Regulation (EU) 2018/848 of the European Parliament and of the Council of 30 May 2018 on organic production and labelling of organic products and repealing Council Regulation (EC) No 834/2007," 2007. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A02018R0848-20220101

of production. The only exception in this is Denmark who questions the trade-offs in emissions due to extensive grazing required by organic standards.

Discussion

The following section will summarize the alignment of all sources, that is the alignment across policies using risk literature to establish whether these are governing for risk. All in all, alignment across risk and policy on an EU level for livestock is lacking. This section will be structured as each prior, according to the six SCAR risk categories.

Risk Assessment: Green House Gas Emissions - EU & MS

Both EU and MS impacts do not align with the risk framing of climate change. While climate change is recognised as important by both sources, the contribution of livestock is not. In MS and EU policies the focus on livestock and ruminants in particular as a main contributor to climate change is lacking. The IPCC and the study by Peyraud and Macleod on the other hand makes it quite clear that livestock is a key node in the problem, even attributing approximately half of EU emissions from agriculture to livestock[200][201]. In addition, the IPCC and Cheng et al., (2022) characterise the negative impacts climate change will have on livestock production[202][203]. These impacts are very rarely mentioned in member state strategies and are entirely neglected in EU policies.

Metrics used by MS and EU policies do not align with the risk assessment done in this report. While the gases considered are quite consistent; nitrogen (ammonia) and methane, the impact on livestock is very limited. There are no metrics to gauge impact on animal production other than one mention of heat stress and water availability used by member states. On an EU level there are even fewer links made between livestock and climate change. The risk assessment accounts for degrees of warming, emissions such as nitrogen and methane, water availability, heat stress, increased diseases and pest and parasite stress as well as changes in animal production such as milk or meat.

Overall, the solutions proposed by both member states and EU policies are aligned with the risk solutions. The following solutions are quite consistently mentioned across sources: manure management, land management, grazing patterns, feed composition. Solutions that diverge across sources include genetics and broadly speaking adaptation strategies which are associated with tradeoffs. These include infrastructure modifications such as cooling systems or limited grazing which may impact animal welfare.

The boundaries of this category are aligned across EU, MS and risk framing. Each source focuses on ruminants and their contribution to the problem. As mentioned previously, member states and EU policies still focus largely on arable farming. But they do recognise ruminants as contributors to

[200] Shukla et al., "IPCC, 2019: Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems."

[201] Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

[202] Cheng, Muxi, Bruce McCarl, and Chengcheng Fei. "Climate change and livestock production: a literature review." *Atmosphere* 13, no. 1 (2022): 140.

[203] Shukla et al., "IPCC, 2019: Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems."

emissions. The risk assessments frame the livestock contribution to greenhouse gas emissions mostly to ruminants due to enteric fermentation.

Finally, in terms of knowledge characterisation the sources are aligned in their uncertainty. While the risk assessments clearly quantify the range of uncertainty in overall impacts[204], the extent to which animal production contributes to climate change as well as the mitigation potential of certain solutions is uncertain. There is a clear consensus that MS and EU policies recognise the uncertainty surrounding emissions quantification. In particular, it is difficult to determine with certainty which mitigation efforts will offer the most emissions reduction potential. All also conclude that this uncertainty makes management increasingly difficult.

Risk Assessment: Diversity - EU & MS

Neither member states nor EU policies align with the impact described by risk assessments for biodiversity. While all establish that biodiversity loss is a threat, member state and EU policies consistently neglect the livestock contribution to this. Risk assessments establish that the intensification and homogenisation of animal production systems is disrupting ecosystems' capacity to provide ecosystem services, one of which is biodiversity. A main inconsistency here is that EU policies are contradictory on land use, as they encourage extensive grazing but criticise conversion of land for agricultural purposes for the impact on biodiversity and emissions. In addition, the vague and unfocused framing of biodiversity both in EU and member state policies does not allow for clear lines of comparison.

Overall, both EU and member state strategies almost entirely exclude domesticated animals from their policy matrix. Moreover, EU and MS strategies focus on habitats and wild species conservation. Only two member states note indigenous or local breeds in their strategies, while on an EU level the Animal Breeding Regulation is the only policy reinforcing the collection and expansion of genetic resources of domesticated animals. The literature on risk reviewed in this thesis very clearly establish that the metrics such as species diversity and distribution, extinction rates and biodiversity intactness index all reflect poorly on the state of global biodiversity. The EFABIS indicator is not a policy intervention, but rather a monitoring and reporting platform which indicates over half of European sheep, goat, pig and chicken species are at risk of extinction.

Solutions for halting biodiversity loss follow a similar pattern; EU and MS strategies revolve around land and habitat preservation and conservation. Farmed land and animal strategies are largely lacking from EU and MS policies. While EU and MS policies include the importance of monitoring and reporting of genetic resources, these interventions do not extend fully to breeding or other strategies to improve genetic diversity on farms. Risk assessments suggest building on the monitoring and reporting efforts through creating clear definitions and metrics for biodiversity (specifically genetic diversity). Furthermore, sustainability criteria should be established to guide investment into research and development. In essence, risk assessments suggest creating a loop of information gathering, organisation, analysis, guidance and investment to reinforce the continuation of this process.

[204] Netz, Bert, Ogunlade R. Davidson, Peter R. Bosch, Rutu Dave, and Leo A. Meyer. "Climate change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policymakers." *Climate change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Summary for Policymakers.* (2007).

The boundaries for biodiversity are not aligned among risk assessments and MS/EU policies. The latter both focus almost entirely on habitats and wild species. They fail to include metrics, problem statements and clear definitions for biodiversity for animal production systems. Risk assessments make clear statements around a loss of genetic diversity for domesticated animals such as cattle. EU and risk assessments are only aligned in their inclusion of wild species as a measure of biodiversity.

EU policies and risk assessments are aligned in their framing of uncertainty around data collection for biodiversity. This can be attributed to the CAP recognition that there are inconsistencies in data collection for diversity. In addition, livestock's contribution to biodiversity loss has been disputed which implies some uncertainty of the benefits around potential interventions in animal production. As Kok[205] claims "Tradeoffs between areas of concern such as greenhouse gases, animal health and welfare and diversity add to the complexity of assessing the benefits of intensive or extensive animal production. Livestock can be said to drive biodiversity loss, but also to reverse and conserve its status.". While the uncertainty established in the risk assessments is not of the same nature as the CAP uncertainty, the presence of a critical lens in reference to data and ensuing assumptions is sufficient to establish alignment between EU and risk framing of knowledge characterisation. Any member state framing of uncertainty is lacking altogether. This may be due to the lack of metrics, definitions and indicators.

Risk Assessment: Economy – EU & MS

Impacts are not aligned between EU and MS policies. While there is clear messaging across EU and MS policies that there is a funding gap and a need to close it, there is no clear indication of what will happen in the absence of funding. Both on EU and MS levels the role of livestock and livestock farmers is not covered. Risk assessments on the other hand include clear statements on the inability for livestock farming to continue without current subsidies[206]. Without funding, according to these risk assessments, the livestock sector is not a viable venture. To reiterate an observation from the literature review section of this thesis, myriad assessments by EU Member States paired with literature have established the negative impacts of intensive animal agriculture and yet there are no concrete instruments promoting the phasing out or reduction of such practices[207].

In terms of metrics, there is no alignment among inputs. EU level metrics consist of CAP instruments to funnel support from the EU budget to member states and their farmers. This process operates at an entirely different system than the risk assessments suggest is needed to facilitate a transition. Risk assessments broadly recommend a blend of funding from both private and public sources such as international private and blended investment management institutions, commercial banks, local financial institutions, and main international philanthropies[208]. This also diverges from the member state approach, which focuses on agriculture as a sector without distinguishing between its arable or livestock components. Member states also fail to include a variety of funding streams and focus on centralised funding either at the EU or national level.

The solutions proposed by member states and EU level policies do not align with the risk assessments. The range of solutions named by MS and EU strategies include national subsidy programs, education

[205] Kok, A., E. M. de Olde, I. J. M. de Boer, and R. Ripoll-Bosch. "European biodiversity assessments in livestock science: A review of research characteristics and indicators." *Ecological Indicators* 112 (2020): 105902.
[206] CLAUDIA, VINCI. "European Union beef sector: Main features, challenges and prospects." (2022).
[207] European Environmental Agency. "Transforming Europe's Food System - Assessing the EU Policy Mix." Publications Office of the European Union, 2022. https://doi.org/10.2800/295264.
[208] World Bank. "Opportunities for Climate Finance in the Livestock Sector: Removing Obstacles and Realizing Potential." (2021).

and training, trade policies, true cost accounting, research and innovation, as well as self-sufficiency (in general less dependence on globalised supply chains). Yet, on a risk assessment level the solutions are as follows: trade policies, funding of research and innovation, development of sustainability tools and criteria, clear sectoral policies to set standards, as well as project-based financing[209]. In general, none of the strategies are directly targeting livestock as a separate industry, rather they are proposing general funding methods for agriculture.

The boundaries between MS and risk assessments cannot be determined. This is due to the lack of time horizons, scale, scope and clarity associated with financial mechanisms needed to target a transition. The EU is not aligned with risk assessments as EU policy focuses almost entirely on CAP financing to promote sustainable agricultural practices. Figure 9 shows how the World Bank suggests streams of funding could look for the livestock sector. It is evident that these streams extend beyond CAP boundaries.

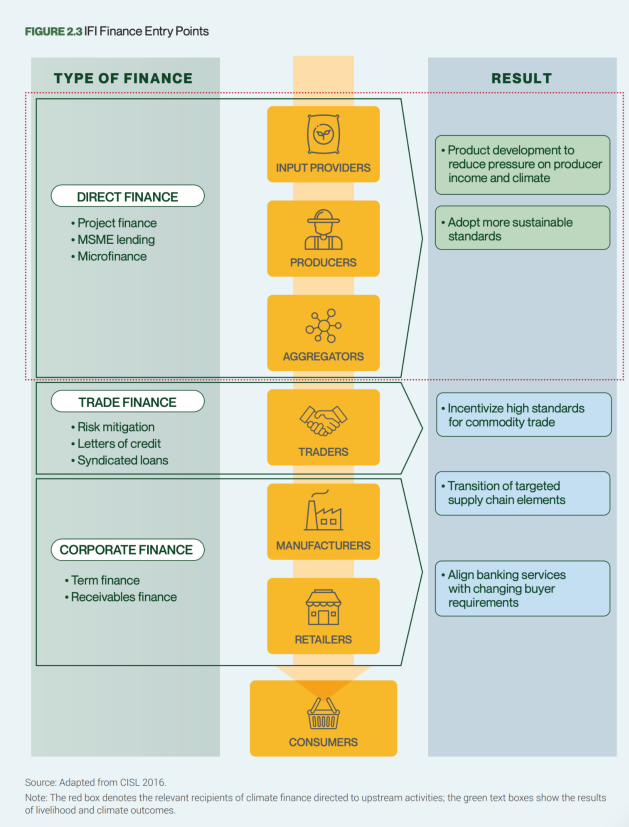


Figure 9: Streams of potential funding for the livestock sector. World Bank 2021.

Lastly, knowledge characterisation between EU and MS policy and risk assessments is inconclusive. Risk assessments recognise the lack of linkages made between (climate) finance and livestock[210]. This link is not made in EU or MS policies. EU focus is on the CAP, which limits the flexibility of streams of funding as CAP reforms take place every four years. This means under the current 2023-2027 CAP metrics and standards are locked in until after 2027.

Risk Assessment: Consumption - EU & MS

209 World Bank. "Opportunities for Climate Finance in the Livestock Sector: Removing Obstacles and Realizing Potential." (2021).

210 World Bank. "Opportunities for Climate Finance in the Livestock Sector: Removing Obstacles and Realizing Potential." (2021).

Impacts are not aligned across EU and member state policies when compared to risk literature. While on a member state level there is somewhat more attention paid to nutrition and health, in line with EU policies, there is an overall lack of a nutritional focus and the impacts of poor nutrition on health. Repercussions of poor dietary and lifestyle choices are characterised in the risk assessments by non-communicable diseases such as cardiovascular disease, chronic illnesses and obesity[211][212]. While obesity is mentioned by EU and member state policies, other health impacts are not made explicit. In addition, EU and Member state policies consistently neglect animal products and fail to make distinctions between nutritional profiles of different types of foods or diets. This stands in stark contrast with the following claim made by the Lancet "Unhealthy diets pose a greater risk to morbidity and mortality than does unsafe sex, and alcohol, drug, and tobacco use combined."[213]. It is clear that the characterisation of the impact of ASF on human health diverges significantly among EU and MS policies in comparison to risk assessments.

Following the lack of alignment throughout the consumption category, metrics are not aligned among sources. In line with the absence of tangible impacts of poor diets, metrics for health and well-being in consumers are not mentioned by EU or member state policies. The only exception to this is a brief mention of obesity and diet related deaths, which are not elaborated upon in terms of causes or micro/macro nutrients that may be causing this. Risk assessments measure health impacts of the consumption of animal products to the prevalence of obesity, cardiovascular disease and deaths attributed to cancer (colorectal). Percentage risks for cancer are linked to intakes of red and processed meats, "... risks increased by 17% for each additional consumption of 100 grams of red meat per day and by 18% for each additional consumption of 50 grams of processed meat per day.[214]". Such distinct evidence for the negative impacts of meat consumption are not consistently included in EU or member state policies.

In terms of solutions, neither member state nor EU policies are aligned with the risk assessments. Overall, the policies suggest a shift to healthy or sustainable diets but either fail to define this (EU), or are inconsistent with their characterisations of healthy or sustainable (MS). Labelling of food products in accordance with their welfare standards or overall quality is popular across EU and member state policies. The risk assessments on the other hand suggest the following; "Balanced diets, featuring plant-based foods, such as those based on coarse grains, legumes, fruits and vegetables, nuts and seeds, and animal-sourced food produced in resilient, sustainable and low-GHG emission systems, present major opportunities for adaptation and mitigation while generating significant co-benefits in terms of human health.[215]". Other approaches suggested by risk assessments include protein diversification, school meal programmes, a shift in food-based guidelines, improving packaging and labelling to account for nutrition.

The boundaries for consumption are inconclusive across sources. There is a general lack of time horizons for outcomes for health and nutrition, metrics are unclear and inconsistent and finally

[211] European Environmental Agency. "Transforming Europe's Food System - Assessing the EU Policy Mix." Publications Office of the European Union, 2022. https://doi.org/10.2800/295264.

[212] Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

[213] Willett, Walter, Johan Rockström, Brent Loken, Marco Springmann, Tim Lang, Sonja Vermeulen, Tara Garnett et al. "Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems." *The lancet* 393, no. 10170 (2019): 447-492.

[214] Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

[215] Shukla et al., "IPCC, 2019: Climate Change and Land: An IPCC Special Report on Climate Change, Desertification, Land Degradation, Sustainable Land Management, Food Security, and Greenhouse Gas Fluxes in Terrestrial Ecosystems."

definitions of 'healthy and sustainable' for diets are inconsistent. Finally, in terms of knowledge characterisation MS and EU policies are not aligned with risk. The lack of definitions and clarity of healthy diets, consequences of poor consumption choices across and metrics to guide these throughout policies is the main cause of this. The uncertainty surrounding the health impacts of ASF is highlighted by Peyraud and Macleod[216], who conclude that pushing for a reduction in animal product consumption is too simplistic as it does not account for the full range of nutrition and environmental elements included in animal products. Reducing impacts to one micro or macronutrient or one greenhouse gas cannot encompass the full range of what it means to eat animal products.

Risk Assessment: Animal Health & Welfare - EU & MS

The impact is aligned as the problem descriptions across policy levels are fairly consistent. antimicrobial resistance and foodborne illnesses are central to the problem statement in EU, member state and risk assessments. As stated in the literature review section of this report "antimicrobial resistance has been classified by the WHO as one of the top 10 threats to global human health. In addition, the European Centre for Disease Control (ECDC) also recognises antimicrobial resistance as a global threat, and claims that it is currently insufficiently managed at the European level."[217]. This statement summarises the way the issue is characterised on all source levels.

The metrics used for animal health and welfare are not aligned. In EU policies metrics reflect that there is an excess in the use of antimicrobials and that the public health impacts are generally negative. Across policies metrics are not consistent, therefore it is unclear on an EU level how progress and mitigation of the risk will be measured. On a member state level metrics are consistently lacking. This stands in stark contrast with risk assessments, which include the following: prevalence of foodborne zoonotic illnesses originating in or amplified by animal production sites, contamination risks of animal source foods, Europeans infected by zoonotic diseases as well as mortality rates in animals due to disease[218].

In terms of solutions, neither MS policies nor EU policies are aligned with the risk assessments. The latter suggest reducing the intensive nature of animal production systems as well as diversifying the production sites for example by combining different species of cattle in a farm instead of an intensive monoculture that is vulnerable to disease. EU policies do not include solutions like this, instead focusing more on monitoring, reporting and banning the use of certain medicines such as hormones or antibiotics that are used in human treatments. Finally, member states are overall missing targeted antimicrobial resistance interventions outside of the collection of data in tracing animal production conditions such as slaughtering conditions or country of origin.

Due to a lack of time horizons and scope as well as scale of the issue, the boundaries for animal health and welfare across sources are inconclusive on alignment. Lastly, the knowledge characterisation among sources is not aligned. The EU policies recognise uncertainty and a gap in knowledge while member states sparsely confirm a lack of data but do not call for more research. Risk assessments characterise the diversity of European food safety and antimicrobial use across member states and associate uncertainty with the differences in data collection and reporting.

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[216] Peyraud, Jean-Louis, and Michael MacLeod. "Future of eu livestock—how to contribute to a sustainable agricultural sector." *Final Report. Directorate-General for Agriculture and Rural Development (European Commission): Brussels, Belgium* (2020): 82.

[217] World Health Organization. "Antimicrobial resistance surveillance in Europe 2022–2020 data." (2022).

[218] European Food Safety Authority, and European Centre for Disease Prevention and Control. "The European Union One Health 2021 Zoonoses Report." *EFSA Journal* 20, no. 12 (2022): e07666.

Organic Risk - EU & MS

Analysis of the impacts across risk assessments show that the EU and member state policies are not aligned. The positive framing of organic regulation and benefits of production throughout EU and member state strategies do not account for potential trade-offs or limitations of this system of farming. The literature on potential threats facing organic identifies a funding, production and veterinary medicine gap[219][220]. While organic may offer some benefits, the expansion of organic in the EU cannot take place without bridging these gaps.

The metrics for organic are not aligned among EU or member state policies as compared to risk assessments. Member states and EU policies generally account for the land area under organic, and member states also account for the percentage of livestock under organic production. Risk literature incorporates conversion time of conventional systems to organic counterparts as well as time and caloric gaps in feed and food production resulting from said conversion[221]. In addition, the underinvestment in organic breeding and general practices compared to conventional practices has resulted in a significant knowledge gap[222].

The solutions offered by member state and EU policies do not align with risk assessments. Since the solutions in member state and EU strategies are exclusively aimed at expanding the land under organic production, as well as promoting public procurement and promotion of the organic label there is no consideration of the limitations of organic in these. The literature on the barriers to expanding organic production mention the need for a host of measures including but not limited to; improving land tenure and ownership, opening markets to competitiveness, supplying public funding for agroecological research, investment in farmer education and training, as well as farmer involvement in research and development[223]. Clearly, the solutions named by literature offer a broader range of measures through which to integrate organic into the status quo of food production in the EU.

To conclude, while the alignment on the boundaries of organic farming cannot be established based on the input from policy and the risk assessments, knowledge characterisation is not aligned. The literature on organic production clearly reflects on limitations of organic and questions the extent to which it can offer sufficient benefits. In addition, the knowledge and research gap reinforces the notion that not enough is known about the potential for organic to be widely integrated. The lack of critical perspectives on organic legislation throughout EU and member state policies leads to the conclusion that these are not aligned.

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219 Kołoszko-Chomentowska, Zofia, and Aldona Stalgiene. "Barriers to the development of organic farming." *Roczniki (Annals)* 2019, no. 1230-2020-806 (2019).

220 Willer, Helga, Jan Trávníček, Claudia Meier, and Bernhard Schlatter. "The world of organic agriculture 2021-statistics and emerging trends." (2021): 1-336.

221 Kołoszko-Chomentowska, Z., & Stalgiene, A. (2019). Barriers to the development of organic farming. *Roczniki (Annals)*, *2019*(1230-2020-806).

222 Reganold, J., Wachter, J. Organic agriculture in the twenty-first century. *Nature Plants* 2, 15221 (2016). https://doi.org/10.1038/nplants.2015.221

223 Reganold, J., Wachter, J. Organic agriculture in the twenty-first century. *Nature Plants* 2, 15221 (2016). https://doi.org/10.1038/nplants.2015.221

Conclusion

The outset of this thesis established gaps in a number of areas. The mounting literature on the impact of agriculture, in particular of animal agriculture on society establishes the need for a transition of sorts. Risks in the form of environmental, social and economic outcomes result as a consequence of current unsustainable practices. The precautionary principle, embedded in the European approach to risk management, sets out to proactively identify and address risks prior to their tangible consequences becoming evident. With the input of risk assessments as well as European claims about the impact of livestock farming, there is an unmistakable gap in governance and overall acknowledgement of the status quo of livestock production as a risk.

This thesis set out to assess the extent to which there is alignment among member state and European policies alongside risk assessments that represent scientific literature on the state of the impact of livestock farming. This aim rests on the premise that a lack of alignment acts as a barrier to achieving a sustainable livestock sector in the EU. The alignment or lack thereof in for example solutions for consumption-based risk can demonstrate consensus on how to manage consumption (as a component of sustainability) as it pertains to livestock. Establishing where there is alignment and where there are gaps may inform a future policy as alignment could be seen as low hanging fruit that can be more easily implemented than approaches different spheres of governance are not in agreement on.

The absence of a policy outlining how to go about the sustainable management of European livestock systems is true throughout levels of governance, from member state strategies to policies comprising the Green Deal. Equally absent are clear frameworks on standards for good practices of animal production. In addition, there is currently no literature that investigates the governance of livestock across EU policies in the interest of sustainability. Therefore, the finding that there is a broad misalignment across the six categories as well as across levels of policy investigated in this thesis reflects poorly on the governance of livestock in the European Union.

The European approach to risk via the precautionary principle extends to livestock in a very limited way, only reflecting on biosecurity through antibiotic resistance and the use of veterinary medicines. This may also be why the findings for the impacts of the animal health and welfare category are aligned which shows that there is a consistent focus on biosecurity in policies relevant to livestock. The animal health and welfare category is also the only area of investigation where impacts are aligned across EU and member state policies as well as with risk. The threat of antibiotic resistance alongside zoonoses/foodborne diseases and in turn public health is consistent with the literature.

While the EU is outwardly engaging with a transition to become a more sustainable continent, in its policies there is an overwhelming gap in definitions, metrics and indicators that shape sustainability. This trickles down into member state policies as well, continuing the trend of using sustainability as a broad umbrella term without specifying what exactly is meant by ‘sustainable agriculture’ or ‘sustainable farming systems’. This is especially true in the context of sustainability for livestock. Pursuing a sustainable food sector, as the Commission claims it aims to, is not complete without the consideration of livestock. This thesis clearly demonstrates the misalignment of definitions, metrics and indicators for consumption, animal health and welfare, diversity and economy.

While the metrics for livestock are inconsistent, the metrics for organic are consistently targeted at land under organic production. The CAP incentivises hectares under organic both for arable and animal production. Yet, in aiming to expand the number of animals under organic production incentives would need to target livestock heads as opposed to hectares. Currently, the way the CAP is set up could create a perverse incentive for farmers to expand their land area without accordingly expanding their herd size. This may result in trade-offs in emissions from land use change in the conversion to pasture.

The European framing of its ambitions and visions for the future claim there is coherence and consistency in policies aiming to build a sustainable Europe. Yet European policies cannot be fulfilled without the participation of member states in commitments and actions. While the CAP and myriad other policies call for the participation of member states in enforcing rules and applying standards to their own contexts, there is little recognition from member states that collaboration across the Union is needed. Even in the event a framework for sustainable livestock practices is developed, without member state monitoring, reporting and enforcement risks will still fail to be mitigated.

There is a significant lack of alignment between member states and EU policies on the risk associated with the European livestock sector. This applies to almost all parameters used to define risk across almost all categories used to represent sustainability for livestock. There is especially a lack of alignment in animal health and welfare, consumption and diversity. This leads to the conclusion that livestock is not currently sustainable according to the six categories chosen for this thesis. In addition, the characterisation of sustainability overall is vague, ambiguous and intangible. This can be seen in the absence of metrics, definitions and indicators. This means that the problem is yet to be made clear across EU and member state spheres of governance. According to these findings, there is currently a gap in the framing, management and future of the European livestock sector.

Organic agriculture and GHG emissions show the most alignment. Organic agriculture in the EU is characterised by clear rules and standardised practices that fall under the organic label. There are legal as well as financial requirements to fulfil to name products organic. This may result in overall clarity around what practices are expected when farmers intend to engage in organic production, and similarly when governments intend to expand organic production on a regional or national level. For GHG emissions, the international attention to emissions reduction as well as the international effort to set emissions reductions targets may provide an example for member states to follow. In addition, EU level emissions reductions targets can provide structure for member states, so that they can determine what their contribution will be to the goal. This may suggest that overarching European policies and frameworks can stimulate alignment among member state policies, and in turn can result in consistent solutions.

Categories that exhibit a particular lack of alignment include consumption and diversity. The lack of alignment in consumption may be due to the overall diversity in European consumption and production models. While the premise of a ‘sustainable diet’ may be unanimously accepted in the EU, the exact details of what this looks like differ significantly depending on geographical, cultural and temporal contexts. The gap in alignment in the diversity category may be related to the overall lack of a clear definition and benefits of what biodiversity can offer. Without knowing what the intended outcomes are, it may not seem like a wise investment choice.

While overall there is very little alignment, EU policies typically align with one another. It is important to note here that alignment is a measure of consistency. While consistency can be positive for policy, it also leaves many things unsaid. Consistency does not necessarily reflect relevance or effectiveness for

promoting sustainable livestock production. Oftentimes alignment was concluded due to a consistent neglect of livestock-related considerations. Therefore, the presence of alignment does not mean systems are governed according to sustainability. It simply means there is consistency in the framing of the impacts, metrics, solutions, boundaries or knowledge characterization of one of the six topics chosen to guide this thesis.

While the five parameters (listed above) and modified from IRGC used to assess alignment provide some insight into risk, there are many more ways to define and assess risk. This method excluded relevant stakeholders from the analysis. It excluded the influence of power and political dynamics that might exercise pressure on the livestock sector. Furthermore, the review of sources was conducted via quick searches and skim reading of the text. This leaves room for human error and the unintentional exclusion of information that may change the assessments of alignment. Therefore, it is necessary to note here that these assessments of alignment are not extensive nor all-encompassing. They are a representation of the current state of policy in the EU compared with risk for the sector in general. To add to this, the nature of the sources used means there is no inclusion of policies on a regional or local level in the EU. Only the EU Commission, Parliament and centralised national policies were used for input. This means that there may be more nuanced and consistent policies beyond those used in this thesis.

Finally, the literature used to reflect risk was not limited to European research. This means that the assumptions and claims made are not specifically targeted at European contexts. This leaves room for a gap in the comparability of data. As in, risk assessments accounting for global threats to the livestock industry may not apply to European livestock systems. This is where extensions of this research can bridge knowledge gaps. There is an urgent need for more specific research into European livestock systems and their needs in terms of sustainability. That said, in order to streamline policy instruments for the sake of sustainability, a definition as well as metrics and indicators need to be developed. Without characterising the nature of the problem consistently, it may be impossible to create coherent and consistent solutions. Once these definitions and indicators have been established, there is a need for an analysis of the barriers to the adoption of practices that mitigate threats to sustainability. Climate conditions, technology and innovation as well as cultural dynamics are ever changing, which is why policy needs to facilitate flexibility. The future is uncertain, but what is certain is that the status quo of livestock production in the European Union is at risk and is being improperly governed.

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Appendices

Appendix 1

Overview of the policies integrated into this analysis.

Category	Policy
Emissions	F2F Nitrate Directive Netherlands Nitrogen Approach National Emission reduction Commitments (NEC) Directive Council Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources EU strategy to reduce methane emissions Nutrients - action plan for better management Biodiversity Strategy
Diversity	F2F Biodiversity Strategy One Health approach (WHO) On compliance measures for users from the Nagoya Protocol on access to genetic resources and the fair and equitable sharing benefits arising from their utilisation in the union
Economy	Feed additives regulation Animal Breeding Regulation Farm to Fork Strategy Biodiversity Strategy
Consumption	Farm to Fork Strategy One Health approach (WHO) Regulation (EC) No 1760/2000 [Official Journal L 204, 11.8.2000] Regulation (EC) No 1760/2000 of the european parliament and of the council Council Directive 96/22/EC of 29 April 1996 concerning the prohibition on the use in stock farming of certain substances having a hormonal or thyrostatic action and of ß-agonists, and repealing Directives 81/602/EEC, 88/146/EEC and 88/299/EEC General Food Law Feed additives regulation EU Regulation No 1151/2012 On quality schemes for agricultural products and foodstuffs Animal Health Law Regulation on the protection of biotechnological inventions Regulation 2018/848 on organic production and labelling of organic products
AHW	Commission Delegated Regulation (EU) 2021/1760 Framework for veterinary medicine regulation EU Animal Welfare Platform Biodiversity Strategy Sentience of animals (European Directive on veal calve ‘Directive 91/629/CEE’ and Council Directive 2008/119/EC

	Ban on male piglet castration (without anaesthesia) Article 118 of the EU Veterinary Medicinal Products Regulation (currently underway, in the feedback stage of implementation) Article 13 of the Treaty of the Functioning of the EU European Convention for the protection of animals kept for farming purposes One Health approach (WHO) Regulation (EC) No 1760/2000 [Official Journal L 204, 11.8.2000] Regulation (EC) No 1760/2000 of the european parliament and of the council Council Directive 96/22/EC of 29 April 1996 concerning the prohibition on the use in stockfarming of certain substances having a hormonal or thyrostatic action and of ß-agonists, and repealing Directives 81/602/EEC, 88/146/EEC and 88/299/EEC General Food Law EU legislation for laying hens Feed additives regulation Animal Breeding Regulation Animal Health Law Regulation 2016/2031 on protective measures against pests of plants\ Regulation on the protection of biotechnological inventions Regulation (EU) 2019/5 amended the EU pharmaceutical legal framework & created a legal framework specific to veterinary products
Organic	Regulation 2018/848 on organic production and labelling of organic products Farm to Fork Strategy Organic Action Plan

Appendix 2

Table showing the documents used as data from Member States.

Country	**Report title**
Austria	Langfristige Klimastrategie 2050
Belgium (Wallonia and Flanders)	Vlaams GLB Strategisch Plan 2030-2027
Denmark	AgriFoodTure
Estonia	Agriculture and Fisheries Strategy 2030
Finland	Vision 2040 for Finnish food production
France	National Low Carbon Strategy Roadmap 2018-2022 Food Policy
Germany	Zukunft Landwirtschaft Nutztierstrategie
Greece	Strategic Plan 2014-2020
Italy	National Strategy for a Sustainable and Inclusive Agricultural, Food and Forestry System
Ireland	Food Vision 2030
Netherlands	The Dutch Government's plan to support the transition to circular agriculture Visie landbouw, natuur, en voedsel
Norway	Strategy Antibiotic resistance 2015-2020 Climate strategy - agriculture National strategy for animal welfare
Poland	National Pathway
Portugal	Innovation Agenda for Agriculture 2020-2030
Slovenia	Long-term climate strategy for Slovenia 2050
Spain	Spain's strategy plan for the CAP 2023-27
Sweden	A National Food Strategy for Sweden Evaluation and follow-up of the food strategy
Turkey	National Strategy and Action Plan for Animal Genetic Resources of Turkey
United Kingdom	Government Food Strategy 2022 The Path to Sustainable Farming: An Agricultural Transition Plan 2021 to 2024

Appendix 3

Table showing all results of the assessment of alignment.

Key:
Not Aligned
Aligned
Lack of input/data (or inconclusive)

Among MS					Among EU					MS - EU					MS - Risk					EU - Risk				
Impacts	Metrics	Solutions	Boundaries	Knowledge Characterisation	Impacts	Metrics	Solutions	Boundaries	Knowledge Characterisation	Impacts	Metrics	Solutions	Boundaries	Knowledge Characterisation	Impacts	Metrics	Solutions	Boundaries	Knowledge Characterisation	Impacts	Metrics	Solutions	Boundaries	Knowledge Characterisation
GHG EMISSIONS																								
DIVERSITY																								
ECONOMY																								
CONSUMPTION																								
ANIMAL HEALTH & WELFARE																								
ORGANIC AGRICULTURE																								